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## Description

This invention is in the field of genetic engineering. More particularly, it relates to recombinant viral proteins associated with lymphadenopathy syndrome and/or acquired immune deficiency syndrome.

5 With the discovery of human T-cell lymphotropic Virus-I (HTLV-I) as an infectious agent in humans, it was established that retroviruses could infect humans and could be the etiological agent of disease. After HTLV-I was established, a second retrovirus of the same family, HTLV-II was found in a hairy cell leukemia established strain. Since that time, other human retroviruses have been isolated which are associated with lymphadenopathy syndrome (LAS) and/or acquired immune deficiency syndrome (AIDS) victims. Various  
10 retroviruses have been isolated from individuals with AIDS (sometimes called HTLV-III) or LAS (sometimes called LAV). See for example, Barre-Sinoussi, et al, *Science* (1983) 220:868-871 and Montagnier, et al, Cold Spring Harbor Symposium (1984) in press; Vilmer, et al, *Lancet* (1984) 1:753, Popovic, et al, *Science* - (1984) 224:497 and Gallo, et al, *Science* (1984) 224:500. A comparison of HTLV-III and LAV may be found in Feorino, et al, (1984), supra. See also, Klatzman, et al, *Science* (1984) 225:59-62, Montagnier, et al, *ibid*  
15 (1984) 63-66, and the references cited therein for a survey of the field. A general discussion of the T-cell leukemia viruses may be found in Marx, *Science* (1984) 22:475-477. Levy, et al, *Science* (1984) 225:840-842 report the isolation of ARV (AIDS-associated retroviruses).

At the time of filing this application, these viruses (HTLV-III, LAV, and ARV) were generically referred to as human T-cell lymphotropic retrovirus (hTLR). However, from 1986 onwards the equivalent generic term  
20 "human immunodeficiency virus" (HIV) was adopted as the recognised term for such viruses. Subsequently, a sub-division of the generic group HIV was necessary into HIV-I and HIV-II. Since the application relates to ARV-2 isolates which are HIV-I isolates, HIV-I has been substituted throughout the application for hTLR (HIV) and the claims are accordingly limited to HIV-I. The HIVs (hTLRS) may be shown to be of the same class by being similar in their morphology, serology, reverse transcriptase optima and cytopathology, as  
25 identified in the above references. For example, the reverse transcriptase prefers  $Mg^{+2}$ , and has a pH optima of about 7.8.

DNA clones containing HIV sequences are disclosed in EP-A1-0173529, EP-A1-0178978, EP-A2-0185444 and WO 86/02383.

The present invention provides the following:

30 A recombinant DNA construct useful for the expression of a recombinant polypeptide in a cell containing the construct, the construct comprising control sequences which regulate transcription and translation of the recombinant polypeptide in the cell and a coding sequence regulated by the control sequences, wherein the coding sequence comprises a DNA sequence of at least about 21 bp in reading frame characterised in that the DNA sequence encodes an antigenic HIV-I amino acid sequence of Figure 2  
35 which sequence is immunologically non-cross-reactive with HTLV-I and HTLV-II and is reactive with HIV-I.

A cell comprising a recombinant DNA construct described above wherein the cell expresses the antigenic HIV-I amino acid sequence and is free from other cells which do not express the antigenic HIV-I amino acid sequence.

40 A method of producing a recombinant polypeptide comprising an antigenic HIV-I amino acid sequence wherein a population of the cells described above is cultured under conditions whereby the recombinant polypeptide is expressed.

An immunoassay for detecting antibodies to HIV-I in a sample suspected of containing the antibodies, characterised in that at least one recombinant polypeptide is used to bind the antibodies and the recombinant polypeptide comprises an antigenic env, gag or pol HIV-I amino acid sequence contained in  
45 the sequence shown in Figure 2 which is immunologically non-cross-reactive with HTLV-I and HTLV-II.

A recombinant polypeptide characterised in that it is produced by a cell transformed by a recombinant DNA construct the construct comprising a DNA sequence which encodes an amino acid sequence from an env, gag or pol polypeptide of HIV-I.

50 An article of manufacture for use in an immunoassay for HIV-I antibodies characterised in that it comprises a solid support having bound thereto a recombinant polypeptide described above.

Figure 1 is a restriction map of proviral DNA (ARV-2).

Figure 2 is the nucleotide sequence of ARV-2(9B). The amino acid sequences for the products of the gag, pol, and env genes are indicated. The U3, R, and U5 regions of the LTRs are also designated. The cap site is position +1. A 3 bp inverted repeat at the ends of the LTR, the TATA box at position -29, the  
55 sequence complementary to the 3'-end of the tRNA<sup>lys</sup> at position 183, and the polyadenylation signal at position 9174 are underlined. The overlines indicate the amino sequences determined from virion proteins. The nucleotides at the beginning of each line are numbered, and the amino acids at the end of each line are indicated.

Figure 3 is a flow diagram showing the procedures for making the plasmid pGAG25-10.

Figure 4 is the nucleotide sequence of the p25 gag gene cloned in plasmid pGAG25-10 and the amino acid sequence encoded by that gene.

Figure 5 is the coding strand of the nucleotide sequence cloned in pGAG41-10 for producing the fusion protein p41 gag and the corresponding amino acid.

Figure 6 is a nucleotide sequence coding for ARV-2 p16 gag protein that was cloned into plasmid pta5 to make an expression plasmid for producing p16 gag protein in bacteria.

Figure 7 is a nucleotide sequence that encodes ARV-2 env protein that was used to prepare plasmid pDPC303.

Figure 8 is a nucleotide sequence that encodes ARV-2 p31 protein and is contained in plasmid pTP31.

The HIV-I DNA sequences, either isolated and cloned from proviral DNA or cDNA or synthesized, may be used for expression of polypeptides which may be a precursor protein subject to further manipulation by cleavage, or a complete mature protein or fragment thereof. The smallest sequence of interest, so as to provide a sequence encoding an amino acid sequence capable of specific binding to a receptor, e.g., an immunoglobulin, will be 21 bp, usually at least 45 bp, exclusive of the initiation codon. The sequence may code for any greater portion of or the complete polypeptide, or may include flanking regions of a precursor polypeptide, so as to include portions of sequences or entire sequences coding for two or more different mature polypeptides. The sequence will usually be less than about 5 kbp, more usually less than about 3 kbp.

Sequences of particular interest having open reading frames (Figure 2) define the structural genes for the gag proteins (p16 and p25), the env protein, and the pol protein (p31). It is to be understood that the above sequences may be spliced to other sequences present in the retrovirus, so that the 5'-end of the sequence may not code for the N-terminal amino acid of the expression product. The splice site may be at the 5'-terminus of the open reading frame or internal to the open reading frame. The initiation codon for the protein may not be the first codon for methionine, but may be the second or third methionine, so that employing the entire sequence indicated above may result in an extended protein. However, for the gag and env genes there will be proteolytic processing in mammalian cells, which processing may include the removal of extra amino acids.

In isolating the different domains the provirus may be digested with restriction endonucleases, the fragments electrophoresed and fragments having the proper size and duplexing with a probe, when available, are isolated, cloned in a cloning vector, and excised from the vector. The fragments may then be manipulated for expression. Superfluous nucleotides may be removed from one or both termini using Bal31 digestion. By restriction mapping convenient restriction sites may be located external or internal to the coding region. Primer repair or *in vitro* mutagenesis may be employed for defining a terminus, for insertions, deletion, point or multiple mutations, or the like, where codons may be changed, either cryptic or changing the amino acid, restriction sites introduced or removed, or the like. Where the gene has been truncated, the lost nucleotides may be replaced using an adaptor. Adaptors are particularly useful for joining coding regions to ensure the proper reading frame.

The env domain of the HIV-I genome can be obtained by digestion of the provirus with *EcoRI* and *KpnI* and purification of a 3300 base pair (bp) fragment, which fragment contains about 400 bp of 5' non-coding and about 200 bp of 3' non-coding region. Three different methionines coded for by the sequence in the 5' end of the open reading frame may serve as translational initiation sites.

Digestion of proviral sequences with *SacI* and *EcoRV* provides a fragment of about 2300 bp which contains the gag domain and a second small open reading frame towards the 3' end of the gag region. The gag domain is about 1500 bp and codes for a large precursor protein which is processed to yield proteins of about 25,000 (p25), 16,000 (p16) and 12,000 (p12) daltons. Digestion with *SacI* and *BglII* may also be used to obtain exclusively the gag domain with p12, p25 and partial p16 regions.

Digestion of the previous with *KpnI* and *SstI* provides a fragment containing the portion of the pol domain that encodes p31.

The polypeptides which are expressed by the above DNA sequences may find use in a variety of ways. The polypeptides or immunologically active fragments thereof, may find use as diagnostic reagents, being used in labeled or unlabeled form or immobilized (i.e., bound to a solid surface), as vaccines, in the production of monoclonal antibodies, e.g., inhibiting antibodies, or the like.

The DNA sequences may be joined with other sequences, such as viruses, e.g., vaccinia virus or adenovirus, to be used for vaccination. Particularly, the DNA sequence of the viral antigen may be inserted into the vaccinia virus at a site where it can be expressed, so as to provide an antigen of HIV-I recognized as an immunogen by the host. The gag, pol, or env genes or fragments thereof that encode immunogens can be used.

Another alternative is to join the gag, env, or pol regions or portions thereof to HBsAg gene or pre-S HBsAg gene or immunogenic portions thereof, which portion is capable of forming particles in a unicellular microorganism host, e.g., yeast or mammalian cells. Thus, particles are formed which will present the HIV-I immunogen to the host in immunogenic form, when the host is vaccinated with assembled particles.

5 As vaccines, the various forms of the immunogen can be administered in a variety of ways, orally, parenterally, intravenously, intra-arterially, subcutaneously, or the like. Usually, these will be provided in a physiologically acceptable vehicle, generally distilled water, phosphate-buffered saline, physiological saline, or the like. Various adjuvants may be included, such as aluminum hydroxide, and the dosages, number of times of administration and manner of administration determined empirically.

10 In order to obtain the HIV-I sequence, virus can be pelleted from the supernatant of an infected host cell. A 9 kb RNA species is purified by electrophoresis of the viral RNA in low-melting agarose gels, followed by phenol extraction. The purified RNA may then be used as a template with random primers in a reverse transcriptase reaction. The resulting cDNA is then screened for hybridization to polyA<sup>+</sup> RNA from infected and uninfected cells. Hybridization occurring from infected, but not uninfected cells, is related to the HIV-I.

Genomic DNA from infected cells can be restriction enzyme digested and used to prepare a bacteriophage library. Based upon restriction analysis of the previously obtained fragments of the retrovirus, the viral genome can be partially digested with EcoRI and 9 kb-15 kb DNA fragments isolated and employed to prepare the library. The resulting recombinant phage may be screened using a double-lift screening method employing the viral cDNA probe, followed by further purification, e.g., plaque-purification and propagation in large liquid cultures. From the library, the complete sequence of the virus can be obtained and detected with the previously described probe.

HIV-I DNA (either provirus or cDNA) may be cloned in any convenient vector. Constructs can be prepared, either circular or linear, where the HIV-I DNA, either the entire hTLR or fragments thereof, may be ligated to a replication system functional in a microorganism host, either prokaryotic or eukaryotic cells 25 (mammalian, yeast, arthropod, plant). Micro-organism hosts include *E. coli*, *B. subtilis*, *P. aeruginosa*, *S. cerevisiae*, *N. crassa*, etc. Replication systems may be derived from ColE1, 2  $\mu$  plasmid,  $\lambda$ , SV40, bovine papilloma virus, or the like, that is, both plasmids and viruses. Besides the replication system and the HIV-I DNA, the construct will usually also include one or more markers, which allow for selection of transformed or transfected hosts. Markers may include biocide resistance, e.g., resistance to antibiotics, heavy metals, etc., complementation in an auxotrophic host to provide prototrophy, and the like.

For expression, expression vectors will be employed. For expression in microorganisms, the expression vector may differ from the cloning vector in having transcriptional and translational initiation and termination regulatory signal sequences and may or may not include a replication system which is functional in the expression host. The coding sequence is inserted between the initiation and termination regulatory signals 35 so as to be under their regulatory control. Expression vectors may also include the use of regulatable promoters, e.g., temperature-sensitive or inducible by chemicals, or genes which will allow for integration and amplification of the vector and HIV-I DNA such as tk, dhfr, metallothionein, or the like.

The expression vector is introduced into an appropriate host where the regulatory signals are functional 40 in such host. The expression host is grown in an appropriate nutrient medium, whereby the desired polypeptide is produced and isolated from cells or from the medium when the polypeptide is secreted.

Where a host is employed in which the HIV-I transcriptional and translational regulatory signals are functional, then the HIV-I DNA sequence may be manipulated to provide for expression of the desired polypeptide in proper juxtaposition to the regulatory signals.

45 The polypeptide products can be obtained in substantially pure form, particularly free of debris from human cells, which debris may include such contaminants as proteins, polysaccharides, lipids, nucleic acids, viruses, bacteria, fungi, etc., and combinations thereof. Generally, the polypeptide products will have less than about 0.1, usually less than about 0.01 weight percent, of contaminating materials from the expression host. Depending upon whether the desired polypeptide is produced in the cytoplasm or secreted, the manner of isolation will vary. Where the product is in the cytoplasm, the cells are harvested, 50 lysed, the product extracted and purified, using solvent extraction, chromatography, gel exclusion, electrophoresis, or the like. Where secreted, the desired product will be extracted from the nutrient medium and purified in accordance with the methods described above.

The expression products of the env, gag, and pol genes and immunogenic fragments thereof having 55 immunogenic sites may be used for screening antisera from patients' blood to determine whether antibodies are present which bind to HIV-I antigens. One or more of the recombinant antigens are used in the serological assay. Preferred modes of the assay employ a combination of gag, env, and pol antigens. A combination of p25, P31 and env recombinant antigens is particularly preferred. A wide variety of

immunoassay techniques can be employed, involving labeled or unlabeled antigens or immobilized antigens. The label may be fluorescers, radionuclides, enzymes, chemiluminescers, magnetic particles, enzyme substrates, cofactors or inhibitors, ligands, or the like.

A particularly convenient technique is to bind the antigen to a support such as the surface of an assay tube or well of an assay plate or a strip of material, such as nitrocellulose or nylon, that binds proteins and contact the sample with the immobilized antigen. After washing the support to remove non-specifically bound antisera, labeled antibodies to human Ig are added. The support is then washed again to remove unbound labeled anti-human Ig. The presence of bound analyte is then determined through detection of the label.

ELISA and "dot-blot" assays are particularly useful for screening blood or serum samples for anti-HIV-I antibodies. The ELISA assay uses microtiter trays having wells that have been coated with the antigenic HIV-I polypeptides(s). The wells are also typically post-coated with a non-antigenic protein to avoid non-specific binding of antibodies in the sample to the well surface. The sample is deposited in the wells and incubated therein for a suitable period under conditions favorable to antigen-antibody binding.

Anti-HIV-I antibodies present in the sample will bind to the antigen(s) on the well wall. The sample is then removed and the wells are washed to remove any residual, unbound sample. A reagent containing enzyme labeled antibodies to human immunoglobulin is then deposited in the wells and incubated therein to permit binding between the labeled anti-human Ig antibodies and HIV-I antigen-human antibody complexes bound to the well wall. Upon completion of the incubation, the reagent is removed and the wells washed to remove unbound labeled reagent. A substrate reagent is then added to the wells and incubated therein. Enzymatic activity on the substrate is determined visually or spectrophotometrically and is an indication of the presence and amount of anti-HIV-I antibody-containing immune complex bound to the well surface.

The "dot-blot" procedure involves using hTLR antigen(s) immobilized on a piece or strip of bibulous support material, such as nitrocellulose filter paper or nylon membrane, rather than antigen-coated microtiter trays. The support will also be treated subsequently with a non-antigenic protein to eliminate non-specific binding of antibody to the support. The antigen-carrying support is dipped into the sample and allowed to incubate therein. Again, any anti-HIV-I antibodies in the sample will bind to the antigen(s) immobilized on the support. After a suitable incubation period the support is withdrawn from the sample and dipped repeatedly in wash buffer to remove any unbound sample from the paper. The support is then dipped into the enzyme-labeled antibody to human Ig reagent for a suitable incubation period. Following treatment with the labeled reagent the support is dipped in wash buffer, followed by incubation in the substrate solution. Enzymatic activity, indicating the presence of anti-HIV-I antibody-containing complexes on the support, causes color changes on the support which may be detected optically.

Either of these techniques may be modified to employ labels other than enzymes. The reading or detection phases will be altered accordingly.

The antigenic polypeptides of HIV-I may also be used as immunogens by themselves or joined to other polypeptides for the production of antisera or monoclonal antibodies which may be used for therapy or diagnosis. The immunoglobulins may be from any mammalian source, e.g., rodent, such as rat or mouse, primate, such as baboon, monkey or human, or the like. For diagnosis, the antibodies can be used in conventional ways to detect HIV-I in a clinical sample.

The HIV-I DNA sequences may also be labeled with isotopic or non-isotopic labels or markers and be used as DNA probes to detect the presence of native HIV-I nucleotide sequences in samples suspected of containing same.

The following examples are offered by way of illustration and not by way of limitation.

#### 1. AIDS related virus-2 (ARV-2) purification and preparation of viral RNA.

HUT-78 cells infected with ARV-2 (ATCC Accession No. CRL 8597, deposited on August 7, 1984) were obtained from Dr. Jay Levy, University of California, San Francisco. Cultures were grown for two weeks in RPMI medium with 10% fetal calf serum. Cultures were centrifuged at 2 Krpm for 1 hr at 4°C using a SW-28 rotor. The pellet, containing the virus, was resuspended in 10 mM Tris-HCl, pH 7.5 on ice. The resuspended pellet was treated with 10 µg of DNase (Boehringer-Mannheim) and was layered onto a linear sucrose gradient (15-50% in 10 mM Tris-HCl, pH 7.5, 1 mM EDTA, 20 mM NaCl). The gradient was spun at 34 Krpm for 4 hr at 4°C, in SW-41 rotor. Five 2.5 ml fractions were collected and an aliquot of each was electrophoresed in a 1% agarose, 5 mM methyl mercury hydroxide gel (Bailey and Davidson, *Anal Biochem* (1976) 70:75-85) to determine which contained the 9 kb viral RNA. The fraction containing the viral RNA was diluted to 10 ml in 10 mM Tris-HCl, pH 7.5, 1 mM EDTA and was centrifuged at 34 Krpm for 2 hr at 4°C. The pellet was resuspended in 20 mM Tris-HCl, pH 7.6, 10 mM EDTA, 0.1% SDS, and 200 µg/ml

proteinase K. Incubation was carried out for 15 min at room temperature. The mixture was extracted with phenol and the aqueous phase was made 400 mM NaCl and precipitated with ethanol. The pellet was resuspended in water and stored at -70 °C.

To purify the viral RNA from the nucleic acid pellet obtained as described above, a sample was electrophoresed in a low-melting 1% agarose gel containing 5 mM Methyl mercury hydroxide. After electrophoresis, the gel was stained with 0.1% ethidium bromide and nucleic acid bands were visualized under UV light. The region corresponding to 9 kb was cut from the gel and the agarose was melted at 70 °C for 2 to 3 min in three volumes of 0.3 M NaCl, 10 mM Tris, pH 7.5, 1 mM EDTA. The mixture was extracted with an equal volume of phenol. The aqueous phase was reextracted with phenol and was precipitated with ethanol. The pellet was washed with cold 95% ethanol, air dried, resuspended in water and stored at -70 °C until use. One hundred ml of culture medium yielded 0.5 to 1 µg of purified RNA.

## 2. Synthesis of labeled homologous viral probe.

A <sup>32</sup>P-labeled cDNA was made to the gel purified viral RNA using random primers (calf thymus primers) prepared as described in Maniatis, et al, A Laboratory Manual, Cold spring Harbor, NY, 1982. The reaction mixture contained 2 µl of 0.5 M MgCl<sub>2</sub>; 5 µl of 0.1 M dithiothreitol; 2.5 µl each of 10 mM dATP, 10 mM dGTP and 10 mM dTTP; 2.5 µl calf thymus primer (100A<sub>260</sub>/ml); 0.5 µg viral RNA; 5 µl of actinomycin D (200 µg/ml); 10 µl of <sup>32</sup>P-dCTP (> 3000 Ci/mmol, 1 mCi/ml) and 1 µl of AMV reverse transcriptase (17 units/µl) in a 50 µl reaction volume. The reaction was incubated for 1 hr at 37 °C. The probe was purified away from free nucleotides by gel filtration using a Sephadex® G50 column. The void volume was pooled, NaCl was added to a final concentration of 400 mM and carrier single-stranded DNA to 100 µg/ml, and the cDNA was precipitated with ethanol. The pellet was resuspended in water and incorporated <sup>32</sup>P counts were determined.

## 3. Detection of ARV sequences in polyA+ RNA prepared from infected HUT-78 cells.

PolyA+ RNA was prepared from HUT-78 cells infected with ARV-2, ARV-3 or ARV-4 (three different isolates from three different AIDS patients) and from uninfected HUT-78 cells. The polyA+ RNA was electrophoresed on 1% agarose gels containing 5 mM methyl mercury hydroxide (Bailey and Davidson, supra), was transferred to nitrocellulose filters, and hybridized with the homologous probe prepared as described in Section 2. Hybridizations were carried out in 50% formamide, 3 x SSC at 42 °C. Washes were at 50 °C in 0.2 x SSC. A 9 kbp band was present in all three samples of infected HUT-78 cells. This band was absent in polyA+ from uninfected cells.

## 4. Detection of ARV sequences in infected and non-infected HUT-78 cells.

High molecular weight DNA (chromosomal) was prepared from cultures of HUT-78 cells infected with ARV-2 and from non-infected HUT-78 cells following the procedure of Luciw, et al, Molec and Cell Biol - (1984) 4:1260-1269. The DNA was digested with restriction enzyme(s), electrophoresed in 1% agarose gels and blotted onto nitrocellulose following the procedure described by Southern, (1975), supra. Blots were hybridized with the <sup>32</sup>P-labeled probe (10<sup>5</sup> cpm/blot) in a mixture containing 50% formamide, 3 x SSC, 10 mM Hepes, pH 7.0, 100 µg/ml denatured carrier DNA, 100 µg/ml yeast RNA and 1 x Denhardt's for 36 hr at 42 °C. Filters were washed once at room temperature in 2 x SSC and twice at 42 °C in 0.2 x SSC, 0.1% SDS. Filters were air dried and exposed to X-Omat film using an intensifying screen.

The homologous <sup>32</sup>P-probe to ARV-2 hybridized specifically to two bands in the DNA from infected cells restricted with SacI. These bands were absent when DNA of non-infected cells was used, indicating that the probe is hybridizing specifically to infected cells presumably to the provirus integrated in the chromosomal DNA. The molecular weight of the bands is approximately 5 kb and 3 kb.

In order to determine if different enzymes would cut the proviral sequence, several other restriction digestions of the cell DNA were carried out using EcoRI, SphI or KpnI or double digestions using two of them. Southern results show specific bands hybridizing when DNA of infected cells is used. Figure 1 shows a schematic map of the positions of restriction enzyme sites in the proviral sequence, and indicates fragment sites.

## 5. Cloning of proviral ARV-2 DNA.

High molecular weight cell DNA from infected HUT-78 cells was prepared following the procedure of Luciw, et al, supra. The DNA was digested with *EcoRI*, which cuts once in the provirus, centrifuged in a sucrose gradient and fractions corresponding to 8-15 kb were pooled, dialyzed and concentrated by ethanol precipitation. The bacteriophage  $\lambda$  derivative cloning vector, EMBL-4 (Karn, et al. *Methods Enzymol* (1983) 101:3-19) was digested to completion with a mixture of *EcoRI*, *BamHI* and *Sall* restriction enzymes and the DNA then deproteinized by phenol-chloroform extraction, precipitated with cold ethanol and resuspended in ligation buffer. The EMBL-4 phage DNA and *EcoRI* digest of cellular DNA were mixed and ligated and the resultant recombinant phage genomes packaged *in vitro*. After phage infection of  $\lambda$ -sensitive *E. coli* - (DP50supF), about 500,000 phage plaques were transferred onto nitrocellulose filters, DNA was fixed and the filters were screened with a homologous  $^{32}\text{P}$ -probe prepared as described in Section 2. Eleven recombinant phage out of 500,000 phage annealed in the initial double-lift screening method (Maniatis, et al, *Molecular Cloning*, A Laboratory Manual, NY, 1982) to viral cDNA probe, and these were further plaque-purified and propagated in large liquid cultures for preparation of recombinant DNA. Plaque-purified phage containing ARV DNA were propagated in liquid culture in *E. coli* DP50supF: phage particles were harvested and banded in CsCl gradients and recombinant phage DNA was prepared by phenol extraction followed by ethanol precipitation (Maniatis, et al, supra). One  $\mu\text{g}$  of purified phage DNA was digested with restriction enzymes, electrophoresed on 1% agarose gels, and visualized with ethidium bromide under ultraviolet light. The DNA from these gels was transferred to nitrocellulose and annealed with viral cDNA probe.

One of the 11 phage, designated  $\lambda$  ARV-2(9B), was deposited at the ATCC on 25 January 1985 and given Accession No. 40158.  $\lambda$  ARV-2(9B) contained an insertion of full-length proviral DNA along with flanking cell sequences. Digestion of  $\lambda$  ARV-2(9B) DNA with *SacI* yielded viral DNA fragments of 3.8 kb and 5.7 kb. *EcoRI* digestion of  $\lambda$  ARV-2(9B) produced virus containing DNA species at 6.4 kb and 8.0 kb; a double digest of *SacI* and *EcoRI* gave viral DNA fragments at 3.8 kb and 5.4 kb. This pattern is consistent with that of a provirus linked to cell DNA.

In addition to  $\lambda$  ARV-2(9B), phage was obtained that (1) possessed the left half of the viral genome from the *EcoRI* site in viral DNA extending into flanking cell DNA ( $\lambda$ ARV-2(8A)) and (2) phage that had the right half of the viral genome ( $\lambda$ ARV-2(7D)) from the *EcoRI* site in viral DNA extending into flanking cell DNA. Bacteriophages  $\lambda$ ARV-2(7D) (right) and  $\lambda$ ARV-2(8A) (left) were deposited at the ATCC on October 26, 1984 and given Accession Nos. 40143 and 40144, respectively.

## 6. Polymorphism.

To measure the relatedness of independent ARV isolates, restriction enzyme digests of DNA from HUT-78 cells infected with ARV-3 and ARV-4 were analyzed with the probe made from cloned ARV-2 DNA. The *SacI* digest of ARV-3 DNA was similar to that of ARV-2 whereas the *HindIII* digests displayed different patterns. The *SacI* digest and the *PstI* digest of ARV-4 DNA differed from the corresponding digests of ARV-2 DNA. The intensity of the annealing signals obtained with ARV-3 and ARV-4 samples was much lower (about 10-fold less) than that for ARV-2 DNA probably as a result of the fact that fewer cells were infected in the ARV-3 and ARV-4 cultures. The viral-specific DNA fragments produced by *SacI* treatment of ARV-3 and ARV-4 DNA totaled 9.0-9.5 kbp, a value similar to that of ARV-2 and in consonance with the RNA genome sizes.

## 7. Sequencing of proviral DNA.

Fragments or subfragments of ARV-2 DNA from  $\lambda$  phage 9B were prepared and cloned into M13 according to conventional procedures (Maniatis, et al, supra). Sequencing was performed according to Sanger, et al, *Proc Natl Acad Sci USA* (1977) 74:5463, using the universal M13 primer or chemically synthesized primers complementary to ARV-2 sequence. The sequence is shown in Figure 2.

## 8. Amino acid sequence analysis of p25 and p16 gag coded proteins.

ARV-2 was prepared and purified as described in Section 1. The viral proteins were electrophoresed on an acrylamide gel, and the band corresponding to a 24,000 dalton or 16,000 dalton protein was excised from the gel and used for sequencing. Micro-sequence analysis was performed using Applied Biosystems model 470A protein sequencer similar to that described by Hewick, et al, *J Biol Chem* (1981) 256:7990-7997. Phenylthiohydantoin amino acids were identified by HPLC using a Beckman ultrasphere ODS column



and a trifluoroacetic acid-acetonitrile buffer system as reported by Hawke, et al, Anal Biochem (1982) 120:302-311. Table 1 shows the first 20 amino acids from the amino terminus determined for p25-gag protein and Table 2 shows the first 30 amino acids for p16-gag protein.

TABLE 1

Amino-terminal sequence of p25-gag	
Position	Amino acid
1	Pro
2	Ile
3	Val
4	Gln
5	Asn
6	Leu
7	Gln
8	Gly
9	Gln
10	Met
11	Val
12	(His)
13	Gln
14	Ala
15	Ile
16	(Ser)
17	Pro
18	(Arg, Lys)
19	Thr
20	(Leu)

TABLE 2

Amino-terminal sequence of p16-gag	
Position	Amino acid
1	(Met)
2	Gln
3	Arg
4	Gly
5	Asn
6	Phe
7	Arg
8	Asn
9	Gln
10	Arg
11	Lys
12	Thr
13	Val
14	Lys
15	--- (Cys)
16	Phe
17	Asn
18	--- (Cys)
19	Gly
20	Lys
21	Glu
22	Gly
23	(His)
24	Ile
25	Ala
26	(Lys)
27	Asn
28	(Gly)
29	(Arg)
30	(Ala, Leu)

The amino acid sequence of Table 1 is predicted from the ARV-2 DNA sequence of Figure 2. Therefore, these results confirm that the indicated gag open reading frame is in fact being translated and identifies the N-termini of p25 and p16.

#### 9. Expression of p25 gag protein of ARV-2 in bacteria.

##### A. Host-vector system

The p25 gag protein is synthesized by *E. coli* strain D1210 transformed with plasmid pGAG25-10.

Plasmid pGAG25-10 is a pBR322 derivative which contains the sequence coding for p25 gag under transcriptional control of a hybrid tac promoter (De Boer et al, PNAS (1983), 80:21-25) derived from sequences of the trp and the lac UV5 promoters. Expression of p25 gag is induced in bacterial transformants with isopropylthiogalactoside (IPTG).

*E. coli* D1210, a lac-repressor overproducing strain, carries the lacI<sup>q</sup> and lacY<sup>+</sup> alleles on the chromosome but otherwise is identical to *E. coli* HB101 (F<sup>-</sup> lacI<sup>+</sup>, lacO<sup>+</sup>, lacZ<sup>+</sup>, lacY<sup>-</sup>, gal<sup>-</sup>, pro<sup>-</sup>, leu<sup>-</sup>, thi<sup>-</sup>, end<sup>-</sup>, hsm<sup>-</sup>, hsr<sup>-</sup>, recA<sup>-</sup>, rpsL<sup>-</sup>) from which it was derived.

##### B. Construction of pGAG25-10.

Plasmid pGAG25-10 was constructed by cloning a 699 bp DNA fragment coding for p25 gag into plasmid ptac5, according to the scheme shown in Figure 3. The vector ptac5 is a pBR322 derivative which

contains the tac promoter. Shine Delgarno sequences, and a polylinker as a substitution of the original pBR322 sequences comprised between the EcoRI and PvuII restriction sites.

The 699 bp DNA fragment codes for the complete p25 gag protein (amino acid residues 139 to 369 as numbered in Figure 2), the only difference being that a methionine was added as the first amino acid in pGAG25-10 to allow for translational initiation. This change, as well as other changes in nucleotide sequence as indicated below, was achieved by using chemical synthesis of party of the DNA fragment. The DNA fragment also includes two stop codons at the 3' end of the sequence.

Figure 4 shows the nucleotide sequence cloned in pGAG25-10 and the amino acid sequence derived from it. DNA sequences that are not underlined in the figure were derived directly from the ARV-2(9B) cDNA. All other sequences were chemically synthesized or derived from vector ptac5. Changes were introduced in this DNA sequence, with respect to the original cDNA, to create or delete restriction sites, to add a methionine prior to the proline (first residue of p25) or to include stop codons after the last codon of p25 gag. However, as previously indicated, all changes in the DNA sequence, except those in the first codon, do not alter the amino acid sequence of p25 gag.

#### C. Preparation of D1210 (pGAG25-10) strain and characterization of p25 gag protein expressed by transformants.

*E. coli* D1210 cells are made competent for transformation following a standard protocol (Cohen et al, PNAS (1972) 69:2110). Transformation is performed as indicated in the protocol with 25-50 ng of pGAG25-10. The transformation mix is plated on agar plates made in L-broth containing 100 µg/ml ampicillin. Plates are incubated for 12 hr at 37°C.

Single ampicillin resistant colonies are transferred into 1 ml L-broth containing 100 µg/ml ampicillin and grown at 37°C. Expression of p25 gag protein is induced by adding 10 µl of 100 mM IPTG (Sigma) to a final concentration of 1 mM followed by incubation at 37°C for 2 hr.

Cells from 1 ml of induced cultures are pelleted and resuspended in 100 µl Laemmli sample buffer. After 3 cycles of boiling and freezing, portions of resultant lysates are analyzed on standard denaturing acrylamide gels. Proteins are visualized by staining with Coomassie blue.

The extent of expression is initially determined by appearance of new protein bands for induced candidate samples compared with control. Proteins of molecular weights expected for the genes expressed comprised 2%-5% of total cell protein in the highest expressing recombinants as determined by visual inspection with reference to a standard protein of known amount.

Authenticity of the expressed proteins is determined by standard Western transfer of proteins to nitrocellulose and analysis with appropriate human or rabbit immune sera or mouse monoclonal antibodies (see E.4.a. below) or by ELISA assays of soluble *E. coli* proteins using human immune sera from AIDS patients (see E.4.b. below).

#### D. Fermentation process.

##### D.1. Preparation of transformant master seed stock.

Transformant cells from a culture expressing high levels (3%) of p25 gag are streaked onto an L-broth plate containing 100 µg/ml ampicillin and the plate is incubated overnight at 37°C. A single colony is inoculated into 10 ml of L-broth, 100 µg/ml ampicillin and grown overnight at 37°C. An aliquot is used to verify plasmid structure by restriction mapping with *Sall* and *PstI*. A second aliquot is used to induce expression of p25 gag and the rest of the culture is made 15% glycerol by adding 1/4 volume of 75% sterile glycerol. Glycerol cell stocks are aliquoted in 1 ml and quickly frozen in liquid nitrogen or dry-ice ethanol bath. These master seed stocks are stored at -70°C.

##### D.2. Master plate/single colonies and overnight cultures.

The master seed stock is scraped with a sterile applicator which is used to streak an L-broth plate containing 100 µg/ml ampicillin. Single colonies from this plate are used to inoculate 20-50 ml of L-broth/amp, which is incubated at 37°C overnight.

### D.3. Fermentor inoculum.

An aliquot of the overnight culture is used to inoculate larger volumes (1-6 liters) of L-broth/amp. Cells are incubated at 37 °C overnight and reach an O.D.<sub>650</sub> of approximately 5 prior to use as inoculum for the fermenter run.

### D.4. Fermentation and harvest.

Fermenters (capacity: 16 liters) containing 10 l of L-broth and 1 ml of antifoam are inoculated with 100-500 ml from the inoculum culture. Cells are grown at 37 °C to an O.D. of about 1. Expression of p25 gag is induced by addition of 100 ml of an IPTG solution (100 mM) to yield a 1 mM final concentration in the fermenter. Cells are grown for 3 additional hours and subsequently harvested using continuous flow centrifugation. At this step cells may be frozen and kept at -20 °C until purification of p25 gag proceeds. Alternatively, 250 l fermenters are inoculated with 1-5 l from the inoculum culture. Growth, induction, and harvest are as indicated before.

## E. Purification and characterization of p25 gag.

### E.1. Cell breakage.

Frozen *E. coli* cells are thawed and suspended in 2.5 volumes of lysis buffer (0.1M sodium phosphate (NaPi), pH 7.5, 1 mM EDTA, 0.1 M NaCl). Cells are broken in a non-continuous system using a 300 ml glass unit of a Dyno Mill at 3000 rpm and 140 ml of acid-washed glass beads for 15 min. The jacketed chamber is kept cool by a -20 °C ethylene glycol solution. Broken cells are centrifuged at 27,000 x g for 25 minutes to remove debris and glass beads. The supernatant is recovered and kept at 4 °C.

### E.2. Selective protein precipitation.

The cell extract is made 30% (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> by slowly adding the ammonium sulfate at 4 °C. The extract is stirred for 10 min after the final concentration is achieved, followed by centrifugation at 27,000 x g for 20 min. The pellet is resuspended in 1 M NaCl, 1 mM EDTA, 1% Triton® X-100, and 5% SDS, and then boiled for 5 min.

### E.3. Gel filtration.

The fraction obtained by selective precipitation is submitted to gel filtration using a G50 Sephadex column equilibrated in 0.03 M NaPi, pH 6.8. Chromatography is developed in the same solution. Fractions are collected and absorbance at 280 nm is determined. Protein-containing fractions are pooled and characterized by protein gel electrophoresis, Western analysis, and ELISA.

### E.4. Characterization of recombinant p25 gag.

a. Protein gel electrophoresis. SDS-polyacrylamide gel analysis (10%-20% gradient gels) of proteins from pGAG25-containing cells and control cells indicated that varying levels of a protein of a molecular weight of about 25,000 were specifically induced in cells containing p25 gag expression plasmids after derepression of the tacI promoter with IPTG. Identity of the p25 gag gene product was confirmed by both an enzyme-linked immunosorbent assay (ELISA, see E.4.c.) and Western immunoblot analysis (see E.4.b.) using both AIDS patient serum and a monoclonal antibody to viral p25 gag.

b. Western analysis. Samples were electrophoresed under denaturing conditions on a 10%-20% polyacrylamide gradient gel. Samples were electroblotted onto nitrocellulose. The nitrocellulose paper was washed with a 1:250 dilution of AIDS patient reference serum (EW5111, obtained from P. Feorino, Centers for Disease control, Atlanta, Georgia) and then with a 1:500 dilution of HRP-conjugated goat antiserum to human immunoglobulin (Cappel, No. 3201-0081). Alternatively, the nitrocellulose was washed with undiluted culture supernatant from 76C, a murine monoclonal antibody to ARV-2 p25 gag, and then with a 1:500 dilution of HRP-conjugated goat antiserum to mouse immunoglobulin (TAGO, No. 6450). The substrate for immunoblots was HRP color development reagent containing 4-chloro-1-naphthol.

The p25 gag protein reacted with both AIDS patient reference serum and with the monoclonal antibody, while it shows no reactivity with the non-immune serum.

c. ELISA. p25 gag was purified from bacterial extracts as previously described. The reactivity of sera with the purified protein was assayed by coating wells of microtiter plates with 0.25 µg/ml, adding dilutions of test sera (positive reference serum EW5111 of human negative serum), followed by a 1:1000 dilution of HRP-conjugated goat antiserum to human immunoglobulin. p25 gag protein reacted with the positive serum with a midpoint of titration curve of approximately 1:800. There was no reactivity with serum from a normal individual.

10. Comparison of recombinant p25 gag protein and natural p25 gag protein in ELISA.

The reactivity of purified recombinant p25 gag to various sera was compared to that of natural p25 gag protein purified by preparative polyacrylamide gel electrophoresis in an ELISA assay. For control, assays were also made using disrupted gradient purified virus (5 µg/ml).

PVC microtiter plates were incubated for 2 hr at 37 °C with 10 µg/ml (50 µl/well in 0.1 M sodium borate, pH 9.0) of the Ig fraction of ascites from murine anti-p25 gag monoclonal antibody 76C. The plates were washed with PBS and the wells were filled with 10% normal goat serum in PBS. Following a 30 min incubation at room temperature, the plates were washed with normal saline containing 0.05% Triton® X-100 (ST) and dilutions of the test ARV protein (50 µl/well in ST with 10% goat serum [STGS]) were added to the wells. The plates were incubated for 2 hr at 37 °C, washed with ST, and then incubated for 1 hr at 37 °C with 50 µl/well of rabbit antiserum raised against disrupted ARV (1:1000 dilution in STGS). The wells were washed, incubated for 1 hr with 50 µl of a 1:1500 dilution in STGS of HRP-conjugated goat antiserum to rabbit immunoglobulin, washed, and then the wells received 50 µl/well of substrate solution (150 µg/ml 2,2'-azino-di-[3-ethylbenzthiazolene sulfonic acid], 0.001% H<sub>2</sub>O<sub>2</sub>, 0.1 M citrate pH 4). The reaction was stopped after incubation for 30 min at 37 °C by the addition of 50 µl/well of 10% SDS. The absorbance was read on a Flow Titertech ELISA reader at 414 nm. Samples were assayed in duplicate beginning at a dilution of 1:10 and by serial 2-fold dilutions thereafter.

The table below summarizes the results of assays on 8 AIDS sera that scored positive in the assay with disrupted virus and 6 normal sera that were negative in the disrupted virus assay.

<u>SERUM NUMBER</u>		<u>ELISA ASSAY TITER<sup>a</sup></u>			
		<u>Disrupted Virus</u>	<u>Recomb. p25 gag</u>	<u>Viral p25 gag</u>	
5	<u>Group I: Sera Scoring As Positive in Virus ELISA<sup>b</sup></u>				
	1	51,200	3,125	3,125	
	5	12,800	25	25	
	6	12,800	625	625	
10	7	12,800	3,125	3,125	
	8	25,600	15,625	15,625	
	9	12,800	625	625	
	13	800	125	125	
15	18	3,200	625	625	
	<u>Group II: Sera Scoring Negative in Virus ELISA<sup>b</sup></u>				
	15	- <sup>c</sup>	-	-	
	16	-	-	-	
20	19	-	-	-	
	21	-	-	-	
	26	-	-	-	
	33	-	-	-	

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- a. Reported as the reciprocal of the serum dilution that gave a signal equivalent to 50% of the maximum.
- b. Results were confirmed by immunofluorescence and immunoblotting as described previously.
- 30 c. No detectable signal at a 1:25 serum dilution.

These results show that p25 gag purified from bacteria behaves identically to similarly purified p25 gag from AIDS virus in an ELISA of the eight AIDS patient sera. The results of the ELISA show that there is a wide variation in the levels of anti-p25 gag antibodies and suggests that antibodies to some virus-encoded proteins may not be detected using conventional virus-based assay systems.

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#### 11. Expression of p41 gag protein of ARV-2 in bacteria.

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A fusion protein of the p25 gag and p16 gag proteins of ARV-2, designated p41 gag, was synthesized in *E. coli* strain D1210 transformed with plasmid pGAG41-10. pGAG41-10 was constructed from plasmid pGAG25-10 as shown in Figure 3 by inserting an *SphI*-*HpaI* fragment from the ARV-2 genome containing the sequences from the C-terminal p16 gag portion of the p53 gag precursor polypeptide and part of the p25 gag protein between the *SphI* and *Bam*HI sites of pGAG25-10. The coding strand of the DNA sequence cloned in pGAG41-10 is shown in Figure 5. Transformation and induction of expression were effected by the procedures described above. The cells were treated and the p41 gag protein was visualized on Coomassie-stained gel as described above. The approximate molecular weight of the observed protein was 41,000 daltons. The protein reacted with AIDS sera and monoclonal antibody to p25 gag in Western and ELISA analyses carried out as above.

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#### 12. Expression of p16 gag protein of ARV-2 in bacteria.

The sequence shown in Figure 6 and coding for the p16 gag protein was chemically synthesized using yeast-preferred codons. The blunt-end *Sall* fragment (381 bp) was cloned into *PvuII*-*Sall* digested and gel-isolated pTac5 (see 9 and 11 above). The resulting plasmid was used to transform D1210 cells, as in 9 above. Expression was induced with IPTG, and proteins were analyzed by polyacrylamide gel electrophoresis and Western analysis. A band of about 16,000 daltons was induced by IPTG in the transformed cells. This protein showed reactivity in Western blots with immune sera from AIDS patients. No reactivity

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was observed with sera from normal individuals.

A recombinant gag protein was also expressed in Cos (mammalian) cells.

### 13. Production of ARV-2 env protein by yeast.

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#### A. Host-vector system.

A partial env protein is synthesized by *S. cerevisiae* 2150-2-3 transformed with plasmid pDPC303. Plasmid pDPC303 is a yeast expression vector which contains the sequence coding for 2/3 of the env protein as well as pBR322 sequences including the amp<sup>R</sup> gene and 2-micron sequences including the yeast leu 2-04 gene. Expression of env is under regulation of the yeast pyruvate kinase promoter and terminator sequences. Yeast strain *S. cerevisiae* 2150-2-3 has the following genotype: Mat a, ade 1, leu 2-112, cir<sup>+</sup>. This strain was obtained from Dr. Leland Hartwell, University of Washington.

#### 15 B. Construction of pDPC303, a yeast expression vector for env protein.

Plasmid pDPC303 contains an "expression cassette" (described below) for env cloned into the BamHI site of vector pCI/I. Vector pCI/I contains pBR322 and 2 micron sequences including the amp<sup>R</sup> and yeast leu 2-04 markers. It was derived from pJDB219d (Beggs, Nature (1978), 275: 104) by replacing the pMB9 region with pBR322 sequences.

The "expression cassette" for env consists of the following sequences fused together in this order (5' to 3'): yeast pyruvate kinase (PYK) promoter, env cDNA, and PYK terminator. The PYK promoter and terminator regions were derived from PYK cDNA isolated as described in Burke, et al, J Biol Chem (1983) 258:2193-2201.

25 The env fragment cloned into the expression cassette was derived from ARV-2 cDNA and comprises a 1395 bp cDNA fragment which codes for env amino acid residues coded by nt 5857 to nt 7251 (Figure 2). In addition, there are 5 extra codons fused in reading frame in the 5' end, the first codon corresponding to a methionine, and 4 extra codons fused in reading frame at the 3' end followed by a stop codon. The extra codons were incorporated to facilitate cloning procedures exclusively.

30 Figure 7 shows the coding strand of the nucleotide sequence cloned in pDPC303 and the amino acid sequence derived from it. DNA sequences that are not underlined in the figure were derived directly from the ARV-2 (9B) cDNA described above. All other sequences were either chemically synthesized or derived from the PYK vector.

#### 35 C. Preparation of 2150 (pDPC303) strain

Yeast cells *S. cerevisiae* 2150-2-3 (Mat a, ade 1, leu 2-04, cir<sup>+</sup>) were transformed as described by Hinnen et al (PNAS (1978) 75:1929-1933) and plated onto leu- selective plates. Single colonies were inoculated into leu- selective media and grown to saturation. Cells were harvested and the env protein was purified and characterized as described below.

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#### D. Purification and characterization of env protein.

##### D.1. Cell breakage.

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Frozen *S. cerevisiae* 2150-2-3 (pDPC303) are thawed and suspended in 1 volume of lysis buffer (1 µg/ml pepstatin, 0.001 M PMSF, 0.001 M EDTA, 0.15 M NaCl, 0.05 M Tris-HCl pH 8.0), and 1 volume of acid-washed glass beads are added. Cells are broken in a non-continuous system using a 300 ml glass unit of Dyno Mill at 3000 rpm for 10 min. The jacket is kept cool by a -20°C ethylene glycol solution. Glass beads are decanted by letting the mixture set for 3 minutes on ice. The cell extract is recovered and centrifuged at 18,000 rpm (39,200 x g) for 35 min. The supernatant is discarded and the precipitate (pellet 1) is further treated as indicated below.

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##### D.2. SDS extraction of insoluble material.

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Pellet 1 is resuspended in 4 volumes of Tris-HCl buffer (0.01 M Tris-HCl, pH 8.0, 0.01 M NaCl, 0.001 M PMSF, 1 µg/ml pepstatin, 0.001 M EDTA, 0.1% SDS) and extracted for 2 hr at 4°C with agitation. The solution is centrifuged at 6,300 x g for 15 min. The insoluble fraction (pellet 2) is resuspended in 4 volumes

(360 ml) of PBS (per liter: 0.2 g KCl, 0.2 g  $\text{KH}_2\text{PO}_4$ , 8.0 g NaCl, 2.9 g  $\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$ ), 0.1% SDS, 0.001 M EDTA, 0.001 M PMSF, 1  $\mu\text{g/ml}$  pepstatin, and centrifuged at  $6,300 \times g$  for 15 min. The pellet (pellet 3) is suspended in 4 volumes of PBS, 0.2% SDS, 0.001 M EDTA, 0.001 M PMSF, 1  $\mu\text{g/ml}$  pepstatin and is extracted for 12 hr at  $4^\circ\text{C}$  with agitation on a tube rocker. The solution is centrifuged at  $6,300 \times g$  for 15 min. The soluble fraction is recovered for further purification as indicated below. (The pellet can be reextracted by resuspending it in 4 volumes of 2.3% SDS, 5%  $\beta$ -mercaptoethanol, and boiling for 5 min. After boiling, the solution is centrifuged at  $6,300 \times g$  for 15 min. The soluble fraction is recovered for further purification.)

#### 10 D.3. Selective precipitation and gel filtration.

The soluble fraction is concentrated by precipitation with 30% ammonium sulfate at  $4^\circ\text{C}$ . The pellet (pellet 4) is resuspended in 2.3% SDS, 5%  $\beta$ -mercaptoethanol, and chromatographed on an ACA 34 (LKB Products) gel filtration column. The column is equilibrated with PBS, 0.1% SDS, at room temperature. 15 Chromatography is developed in the same solution with a flow rate of 0.3 ml/min. Five ml fractions are collected, pooled and characterized by protein gel electrophoresis, Western analysis, and ELISA. If needed, pooled fractions are concentrated by vacuum dialysis on Spectrapor #2 (MW cutoff 12-14K).

#### 20 D.4. Characterization of recombinant env.

SDS polyacrylamide gel analysis (12% acrylamide gels) showed that a new 55,000 dalton protein was being synthesized in yeast cells transformed with the env-containing vector. The 55,000 dalton protein is absent from cells transformed with control plasmid (vector without env insert). The identity of env was confirmed by both ELISA (see 9.E.4.c) and Western analysis using AIDS patient serum. In both assays the 25 55,000 dalton protein showed immunoreactivity. No reactivity was obtained with serum from a normal individual.

Recombinant env was also expressed in mammalian (Cos) cells.

#### 14. Expression of p31 pol protein of ARV-2 in bacteria.

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##### A. Host vector system

The C-terminal region of the polymerase gene (p31 pol) is synthesized by E. coli strain D1210 transformed with plasmid pTP31.2. Plasmid pTP31.2 is a pBR322 derivation which contains the sequence 35 coding for p31 under transcriptional control of the hybrid tac promoter (described in 9.A). Expression of p31 is induced in bacterial transformants by IPTG.

##### B. Construction of pTP31.2.

#### 40 B.1. Construction of M13 template 01100484.

A 5.2 kb DNA fragment was isolated from a KpnI digest of ARV-2 (9b) containing the 3' end of the pol gene, orf-1, env and the 5' end of orf-2, that had been run on a 1% low melting point agarose (Sea-Pack) gel and extracted with phenol at  $65^\circ\text{C}$ , precipitated with 100% ethanol and resuspended in TE. Eight  $\mu\text{l}$  of 45 this material were further digested with SstI for 1 hr at  $37^\circ\text{C}$  in a final volume of 10  $\mu\text{l}$ . After heat inactivation of the enzyme, 1.25  $\mu\text{l}$  of this digest were ligated to 20 ng of M13mp19 previously cut with KpnI and SstI, in the presence of ATP and in a final volume of 20  $\mu\text{l}$ . The reaction was allowed to proceed for 2 hr at room temperature. Five  $\mu\text{l}$  of this mixture were used to transform competent E. coli JM101. Clear plaques were grown and single-stranded DNA was prepared as described in Messing and Vieira, Gene - 50 (1982) 19:269-276.

#### B.2. In Vitro mutagenesis of 01100484.

The DNA sequence in 01100484 was altered by site specific mutagenesis to generate a restriction site 55 recognized by NcoI (CCATGG). An oligodeoxynucleotide that substitutes the A for a C at position 4299 (Figure 2) and changes a T for an A at position 4305 (Figure 2) was synthesized using solid phase phosphoramidite chemistry. Both of these changes are silent in terms of the amino acid sequence, and the second one was introduced to decrease the stability of the heterologous molecules. The oligomer was



named ARV-216 and has the sequence: 5'-TTAAATCACTTGCCATGGCTCTCCAATTACTG and corresponds to the non-coding strand since the M13 derivative template 01100484 is single-stranded and contains the coding strand. The 5' phosphorylated oligomer was annealed to the 01100484 M13 template at 55°C in the presence of 5' dephosphorylated M13 sequence-ing primer, 50 mM Tris-HCl pH 8, 20 mM KCl, 7 mM MgCl<sub>2</sub> and 0.1 mM EDTA. The polymerization reaction was done in 100 µl containing 50 ng/µl DNA duplex, 150 µM dNTPs, 1 mM ATP, 33 mM Tris-acetate pH 7.8, 66 mM potassium acetate, 10 mM magnesium acetate, 5 mM DTT, 12.5 units of T4 polymerase, 100 µg/ml T4 gene 32 protein and 5 units of T4 DNA ligase. The reaction was incubated at 30°C for 30 min and was stopped by the addition of EDTA and SDS (10 mM and 0.2% respectively, final concentration). Competent JM101 *E. coli* cells were transformed with 1, 2, and 4 µl of a 1:10 dilution of the polymerization product and plated into YT plates. Plaques were lifted by adsorption to nitrocellulose filters and denatured in 0.2 N NaOH, 1.5 M NaCl, followed by neutralization in 0.5 M Tris-HCl pH 7.3, 3 M NaCl and equilibrated in 6 x SSC. The filters were blotted dry, baked at 80°C for 2 hr and preannealed at 37°C in 0.2% SDS, 10 x Denhardt's, 6 x SSC. After 1 hr, 7.5 million CPM of labeled ARV-216 were added to the filters and incubated for 2 additional hr at 37°C. The filters were washed in 6 x SSC at 42°C for 20 min, blot-dried and used to expose film at -70°C for 1 hr using an intensifying screen. Strong hybridizing plaques were grown and single-stranded DNA was prepared from them and used as templates for sequencing. Sequencing showed that template 01021785 contains the NcoI site as well as the second substitution mentioned above.

A second oligomer was synthesized to insert sites for Sall and EcoRI immediately after the termination codon of the pol gene (position 5101, Figure 2). This oligomer was called ARV-248 and has the sequence: 5'-GGTGTCTTACTAAAGAATTCGTCGACTAATCCTCATCC. Using the template 01020785, site specific mutagenesis was carried out as described above except that the filter wash after the hybridization was done at 65°C. As above, 8 strong hybridizing plaques were grown and single-stranded DNA was sequenced. The sequence of template 01031985 shows that it contains the restriction sites for NcoI, Sall, and EcoRI as intended.

### B.3. Isolation of NcoI-EcoRI and NcoI-Sall DNA fragments that contain p31.

Replicative form (RF) of the 01031985 template was prepared by growing 6 clear plaques, each in 1.5 ml of 2 x YT at 37°C for 5 hr. Double-stranded DNA was obtained as described by Maniatis, et al, Molecular Cloning, a Laboratory Manual, Cold Spring Harbor, 1982, pooled and resuspended in 100 µl final volume. Ten µl of RF were digested with NcoI and EcoRI in a final volume of 20 µl. This fragment was used for direct p31 expression in bacteria. An additional 20 µl of RF were cut with NcoI and Sall in 40 µl. This fragment was used for p31 expression in yeast. The samples were run on a 1% low melting point agarose (Sea-Pack) gel and the DNAs were visualized by fluorescence with ethidium bromide. The 800 bp bands were cut and the DNAs were extracted from the gel as mentioned above and resuspended in 10 µl of TE. The fragments were called ARV248NR#2 and ARV248NL, respectively.

### B.4. Cloning of p31 into plot7.

The vector plot7 (3 µg) (Hallewell, et al, Nucl Acid Res (1985) 13, No. 6, pp. 2017-2034) was cut with NcoI and EcoRI in 40 µl final volume and the enzymes were heat-inactivated after 3 hr. Two µl of this digest were mixed with 2 µl of ARV248NR#2 and ligated in 20 µl in the presence of ATP and T4 DNA ligase at 14°C overnight, and 10 µl of this mixture were used to transform competent D1210 cells. Colonies resistant to 2 mM IPTG and 100 µg/ml ampicillin were selected and supercoiled DNA was extracted from each of them. The DNAs were then restricted with NcoI and EcoRI and analyzed by agarose gel electrophoresis. Clones with the appropriate 800 bp insert were selected for further use. They are designated pRSP248 numbers 3 and 4.

### B.5. Construction of pTP31.

The NcoI site introduced into 01100485 is 52 bp downstream from the putative start of p31. Three oligomers were synthesized as above that code for the first 18 amino acids of p31 and generate a cohesive NcoI end at the 3' end of the molecule. The 5' end of the molecule has been extended beyond the initiation codon to include a ribosome binding site. The oligomers that were synthesized have the sequences:

## ARV-221.-

CCCC C C  
 5' AGGXAACAGAAAATGATAGATAAGGCACAAGAA  
 TTTT T

## ARV-222.-

5' GAACATGAGAAATATCACAGTAATTGGAGAGC

## ARV-223.-

3' CGTGTTCCTTCTTGACTCTTTATAGTGTTCATTAAACCTCTCGGTAC

One hundred fifty picomoles each of dephosphorylated ARV-211, phosphorylated ARV-222 and ARV-223 were ligated to 20 µg of pRSP248 previously cut with NcoI, at 14°C for 18 hr in a final volume of 62 µl. After phenol extraction and ethanol precipitation, the DNA was resuspended in 40 µl H<sub>2</sub>O and incubated with 15 units of Klenow fragment in the presence of 0.5 mM dNTPs for 1 hr at room temperature. The sample was phenol extracted, ethanol precipitated, resuspended in 40 µl H<sub>2</sub>O, and digested with EcoRI. The DNA was then run on a low melting point agarose gel and the fragment of about 820 bp was extracted as described above and resuspended in a final volume of 20 µl of H<sub>2</sub>O. After phosphorylating the ends, 5 µl of the sample were incubated for 18 hr at 14°C with 150 ng of pTP31 that had been cut with PvuII and EcoRI and its ends dephosphorylated, in the presence of T4 DNA ligase, ATP and in a final volume of 31 µl. Five µl of ligation product were used to transform RRdeltaM15. Clones resistant to 100 µg/ml of ampicillin were selected and supercoiled DNA was extracted from them. The DNAs were digested with NcoI and EcoRI and resolved on a 1% agarose gel. Colonies with the appropriate size insert were obtained and named pTP31. The p31 sequence contained in the insert is shown in Figure 8. Underlined sequences were chemically synthesized. Others were derived from DNA.

C. Screening of transformants for specific proteins that react with AIDS sera.

Bacterial transformants containing either the vector alone, or the vector with the p31 DNA (pTP31.2) were grown in L-broth with 0.02% ampicillin to an OD<sub>650</sub> of 0.5. Cultures were induced by the addition of IPTG to a final concentration of 2 mM and grown for 3 more hr. Bacteria from 1 ml cultures were pelleted and resuspended in 200 µl of gel sample buffer. The cells were disrupted by three cycles of freezing and thawing, boiled, and the extracts loaded onto 12.5% polyacrylamide-SDS minigels. Proteins were electrophoresed and transferred to nitrocellulose by electroblotting. The nitrocellulose filters were reacted with serum EW5111 (diluted 1:100: positive reference serum from the CDC that reacts strongly with viral p31), horse radish peroxidase-conjugated goat anti-human IgG and HRP substrate. A prominent band at ~30,000 d and several lower molecular weight species were seen in gels of extracts from transformants with the p31 DNA, but not in extracts from bacteria transformed with the vector alone.

D. Demonstration that the polypeptide from the C-terminal region of the pol gene is analogous to the viral p31 protein.

Lysozyme-NP40 extracts were prepared from bacteria transformed with pTP31.2 or vector alone. Five ml cultures were grown, the cells pelleted and resuspended in 1 ml of 50 mM Tris-HCl pH 8, 0.5 mM EDTA, 1 mg/ml lysozyme and incubated at 0°C for 15 min. NaCl, MgCl<sub>2</sub>, and NP40® were added to final concentrations of 0.4, 5 mM and 0.5% respectively, mixed and incubated with DNase I (100 µg/ml) at 0°C for 30 min. When EW5111 serum (diluted 1:100) was preincubated with a 1:10 dilution of the cell extracts from bacteria transformed with pTP31.2, prior to reaction with a virus blot, the viral p31 band was completely eliminated, while reactivity with other viral proteins remained unaffected. In contrast, extracts from bacteria transformed with the vector alone did not absorb out the p31 reactive antibodies. The viral p31 protein is thus the product of the C-terminal or endonuclease region of the pol gene of ARV-2.

15. Expression of p31 pd protein in yeast.A. Construction of a yeast vector p31/GAP-ADH2: Cloning of p31 into pAB24.

- 5 The ARV248NL fragment was cloned into pBS100 previously cut with NcoI and Sall. pBS100 is a bacterial vector derived from pAB12 with a BamHI cassette consisting of the GAP-ADH2 promoter, an ARV-env gene as an NcoI-Sall fragment, and the GAP terminator. The BamHI cassette from two positive clones of pBS100/p31/GAP-ADH2 was cloned into pAB24, a yeast vector with both ura and leu selection capabilities. Both orientations of the cassette in this vector were screened for and used to transform the
- 10 yeast strain AB110 (Mat a, ura 3-52, leu 2-04, or both leu 2-3 and leu 2-112, pep 4-3, his 4-580, cir<sup>+</sup>). These cells were plated in both ura- and leu- plates. Also, ura- cells were plated onto leu- plates.

B. Induction of p31 expression.

- 15 Three different induction procedures were done: 1.- Ura- colonies patched on ura- plates were induced for 24 hr in YEP/1% glucose. Both a Western and a polyacrylamide gel were run on these samples. Both results were negative. 2.- Colonies from ura- plates patched on leu- plates were induced in either leu-/3% ethanol or YEP/1% glucose for 24 hr. A Western and a polyacrylamide gel were run on these samples and the results were also negative. 3.- Colonies from leu-plates patched on leu- plates were induced in either
- 20 leu-/3% ethanol or YEP/1% glucose for 24 hr. The polyacrylamide gel showed a negative result. No Western was run on these samples.

16. Expression of superoxide dismutase (SOD)-p31 fusion protein in yeast.25 A. Construction of pCI/-pSP31-GAP-ADH2 derivative.

- For the construction of a gene for a fused protein SOD-p31 to be expressed in yeast, a plasmid (pSI4/39-2) was used. This plasmid contains the SOD gene fused to the proinsulin gene under the regulation of the ADH-2/GAP promoter. The proinsulin gene is located between EcoRI and Sall restriction
- 30 sites. To substitute the proinsulin gene with the ARV248NL fragment, two oligomers designated ARV-300 and ARV-301, respectively, were synthesized using phosphoramidite chemistry. The sequences generate cohesive ends for EcoRI and NcoI on each side of the molecule when the two oligomers are annealed. ARV-300 and ARV-301 have the sequences:

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ARV-300      5' AATTCAGGTGTTGGAGC  
GTCCACAACCTCGGTAC 5' ARV-301

- 40 Two µg of pSI4/39-2 linearized with EcoRI were ligated to 100 picomoles each of phosphorylated ARV-300 and dephosphorylated ARV-301 in the presence of ATP and T4 DNA ligase in a final volume of 35 µl. The reaction was carried out at 14°C for 18 hr. The DNA was further digested with Sall and the fragments were resolved on a 1% low melting point agarose gel and a fragment containing the vector plus the SOD gene (~6.5 kb) was purified as described above and resuspended in 50 µl of TE. Five µl of this preparation
- 45 were ligated to 5 µl of ARV248NL in 20 µl final volume for 18 hr at 14°C and 5 µl used to transform competent HB101 cells. The resultant plasmid was called pSP31. Twenty µg of this plasmid were digested with BamHI and a fragment of about 2900 bp was isolated by gel electrophoresis, resuspended in TE and ligated to pCI/- previously cut with BamHI. This DNA was used to transform HB101 and transformants with the BamHI cassette were obtained. Yeast strains 2150, PO17, and AB110 were transformed with this pCI/-
- 50 pSP31-GAP-ADH2 derivative, both short and long orientations. The strain 2150 gave no transformants. All other transformants were patched on leu- plates.

B. Induction of pCI/-pSP31-GAP-ADH2.

- 55 Three different kinds of inductions were tried: 1.- PO17 colonies were induced in either a 10 ml culture of YEP/1% glucose or a leu-/3% ethanol culture for 24 hr. The yeast pellets were analyzed by both polyacrylamide gels and Westerns and even though the Coomassie-stained gel showed a negative result, the Western did light up a band of the correct molecular weight with both induction methods. 2.- PO17

colonies were induced in a 30 ml culture of YEP/1% ethanol for 48 hr. Aliquots were analyzed by PAGE at various time points during the induction. The Coomassie-stained gel shows a band in the correct molecular weight range (47-50 kd) that appears after 14 hr in YEP/1% ethanol and reaches a maximum intensity at 24 hr of induction. The Western result correlates well with the Coomassie-stained gel, showing strong bands at 24 and 48 hr. 3.-AB110 colonies were induced in either leu-/3% ethanol or YEP/1% glucose for 24 hr. PAGE and Westerns were run and the results were negative for the PAGE and positive for the Western, in both induction methods.

#### 17. Purification and characterization of SOD-p31 from bacteria or yeast

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Frozen bacteria (yeast) cells are thawed at room temperature and suspended in 1.5 volumes of lysis buffer (20 mM Tris-HCl, pH 8.0, 2 mM EDTA, 1 mM PMSF, for bacteria; 50 mM Tris-Cl, pH 8.0, 2 mM EDTA, 1 mM PMSF for yeast), and mixed with 1 volume of acid-washed glass beads.

Cells are broken for 15 min in a non-continuous mode using the glass chamber of a Dymomill unit at 3,000 rpm, connected to a -20 °C cooling unit. Glass beads are decanted for 2-3 min on ice, the cell lysate is removed. The decanted glass beads are washed twice with 30 ml of lysis buffer at 4 °C. The cell lysate is centrifuged at 39,000 x g for 30 min.

The pellet obtained from the above centrifugation is washed once with lysis buffer, after vortexing and suspending it at 4 °C (same centrifugation as above). The washed pellet is treated with 0.2% SDS (for bacteria) and 0.1% SDS (for yeast) in lysis buffer and is agitated by rocking at 4 °C for 10 min. The lysate is centrifuged at 39,000 x g for 30 min. The pellet is boiled in sample buffer (67.5 mM Tris-Cl, pH 7.0, 5%  $\beta$ -mercaptoethanol, 2.3% SDS) for 10 min and centrifuged for 10 min at 39,000 x g. The supernatant is recovered and further centrifuged at 100,000 x g for 60 min (60 Ti rotor). This step is replaced by a 0.45  $\mu$ m filtration when yeast is used. The supernatant from the above centrifugation is loaded (maximum 50 mg of protein) on a gel filtration column (2.5 x 90 cm, ACA 34 LKB) with a flow rate of 0.3-0.4 ml/min, equilibrated with phosphate-buffered saline (PBS), 0.1% SDS. The fractions containing SOD-p31 are pooled and concentrated either by vacuum dialysis or using a YM5 Amicon membrane at 40 psi. The protein is stored at -20 °C as concentrated solution.

Gel electrophoresis analysis shows that the SOD-p31 protein migrates having a molecular weight of about 46 kd and is over 90% pure.

#### 18. ELISA for antibodies to HIV-I using recombinant ARV-2 polypeptides

Stock solutions of purified p25 gag protein (1.25 mg/ml in 20 mM sodium phosphate, 0.1% SDS, pH 7.2), purified env protein (2 mg/ml in 20 mM sodium phosphate, 0.1% SDS, pH 7.2), and purified SOD-p31 fusion protein (2 mg/ml in 20 mM sodium phosphate, 0.1% SDS, pH 7.2) were prepared.

For coating microtiter plates (Dynatech Immulon I), 1 part each of the stock solutions of p25 gag, env, and SOD-p31 were added to 997 parts of borate coating buffer (0.05 M borate, pH 9.0). One hundred microliters of the coating solution was added to each well, and the plates were covered and incubated 2 hr at 37 °C or 12 hr at 4 °C. The coating solution was then aspirated from the wells and the plates washed 6 x with wash solution (0.137 M 0.8% NaCl, 0.05% Triton® X-100).

Serum samples were diluted 1:100 in dilution solution (0.1% casein, 1 mM EDTA, 1% Triton® X-100, 0.5 M NaCl, 0.01% thimerosal, pH 7.5) with yeast protein (strain AB103.1) extract (1:40 dilution, approximately 2 mg protein per ml in PBS containing 1% Triton X-100, 2 mM PMSF, 0.01% thimerosal) and *E. coli* protein extract (1:40 dilution, approximately 1 mg protein per ml in PBS containing 1% Triton® X-100, 2 mM PMSF, 0.01% thimerosal) added to the dilution solution. Extraction procedures were similar to those described in 13 and 14 above but using non-recombinant strains. One hundred microliters of diluted serum was added to each well and incubated 30 min at 37 °C. The plates were then washed 6 x with wash solution.

Goat anti-human Ig labeled with horseradish peroxidase (Cappel) diluted 1:8000 in dilution solution without added yeast and *E. coli* extracts were added at 100  $\mu$ l/well to the plates and incubated 30 min at 37 °C. The plates were then washed 6 x with wash solution. Substrate solution (10 ml citrate buffer, 10.5 g citric acid/liter dH<sub>2</sub>O, pH to 4.0 with 6 M NaOH), 0.1 ml ABTS (15 mg/ml 2,2'-azino-di-(3-ethyl-benz-thiazolene sulfonic acid) in dH<sub>2</sub>O) and 3.33  $\mu$ l H<sub>2</sub>O<sub>2</sub>) at 100  $\mu$ l/well was then added to the plates and the plates wrapped in foil and incubated at 37 °C for 30 min. The reaction was then stopped by adding 50  $\mu$ l/well of 10% SDS. Readings were made with a Dynatech ELISA reader set for dual wavelength reading: absorbance wavelength of 1 (410 nm) and reference wavelength of 4.

Results

The following sera were tested:

5 A. 89 consecutive blood donors from the Kansas City Blood Bank ("normal blood donors"): log nos. 1001-1081, 1085-1092.

B. 52 sera from patients with lymphadenopathy syndrome (LAD) or AIDS or sexual partners of persons with LAD or AIDS (referred to as "contacts")--all obtained from UCSF AIDS Serum Bank panel: log nos. 4601-4652.

10 The positive/negative cut-off used was  $5 \times$  (average background signal - signal with diluent alone) and was determined to be 0.195. Thus, sera with signals below 0.195 were rated (-); those above were rated (+). Each sample was also evaluated by the commercially available ABBOTT HTLV III EIA kit (Abbott Labs) and by Western analysis.

15 Tests on the normal blood donor samples indicated all except one were negative in the invention ELISA. This normal serum scored negative in the ABBOTT HTLV III EIA test, but was actually positive, as confirmed by Western analysis.

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The results of the tests on the 52 sera from LAD and AIDS patients and contacts are tabulated below:

	Serum No.	Diagnosis	ABBOTT EIA	Invention ELISA	Western
5	4601	Contacts	+	1.89	+
	02	Contacts	-	0.04	-
	03	Contacts	+	1.44	+
10	04	Contacts	+	1.92	+
	05	Contacts	-	0.04	-
	06	Contacts	+	>2	+
	07	Contacts	+	1.37	+
	08	Contacts	+	1.60	+
15	09	Contacts	+	>2	+
	10	Contacts	+	>2	+
	11	Contacts	+	1.94	+
	12	Contacts	+	>2	+
	13	Contacts	+	>2	+
20	14	Contacts	+	>2	+
	15	Contacts	+	1.97	+
	16	AIDS	+	0.61	+
	17	AIDS	+	>2	+
	18	AIDS	+	>2	+
25	19	AIDS	+	1.58	+
	20	AIDS	+	1.58	+
	21	AIDS	+	0.76	+
	22	AIDS	+	1.74	+
	23	LAD	+	1.26	+
30	24	LAD	+	>2	+
	25	AIDS	+	1.04	+
	26	AIDS	+	1.24	+
	27	AIDS	+	1.40	+
	28	AIDS	-	0.07	-
35	29	LAD	+	1.93	+
	30	Contacts	+	1.96	+
	31	AIDS	+	1.76	+
	32	AIDS	+	0.90	+
	33	AIDS	+	1.69	+
40	34	LAD	+	1.09	+
	35	AIDS	+	1.54	+
	36	AIDS	+	1.22	+
	37	AIDS	+	1.96	+
	38	AIDS	-	>2	+
45	39	LAD	+	1.85	+
	40	LAD	+	>2	+
	41	LAD	+	0.84	+
	42	LAD	+	1.59	+
	43	LAD	+	1.71	+
50	44	AIDS	+	1.40	+
	45	LAD	+	>2	+
	46	AIDS	+	1.38	+

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	Serum No.	Diagnosis	ABBOTT EIA	Invention ELISA	Western
	47	AIDS	+	1.29	+
5	48	LAD	+	1.93	+
	49	LAD	+/-	0.48	+
	50	LAD	-	0.04	-
	51	LAD	-	0.07	-
10	52	LAD	+	1.92	+

The above results show that the invention ELISA using recombinant ARV proteins is at least as good as the ABBOTT HTLV III EIA test or Western analysis.

In the invention ELISA reported in this example the yeast and bacterial extracts were added to the serum to bind serum antibodies to yeast and bacteria to prevent such antibodies from binding to the recombinant ARV-2 proteins. Both yeast and bacterial extracts were required since the recombinant polypeptides included polypeptides expressed in yeast and polypeptides expressed in bacteria. If all the polypeptides were expressed in the same type of organism, only one extract would be needed. For instance, if a p25 gag polypeptide expressed in yeast was substituted for the bacterially produced p25 gag polypeptide of the example, only yeast extract would be added to the serum samples.

#### 19. Dot-blot assay for antibodies to HIV-I using recombinant ARV-2 polypeptides.

Nitrocellular strips (0.5 x 5 cm) are spotted with 50 ng polypeptide in PBS (spotting volume 2 µl). After spotting the strips are dried at room temperature for 1 hr or more. The strips are then post-coated in a 5% solution of Carnation non-fat dry milk in PBS, 0.01% Thimerosal, for 15-60 min at room temperature. Each test solution sample is diluted 1:50 in 0.5 ml of the post-coating solution in a test tube. A post-coated strip is then placed in the tube and incubated in the sample with rocking at 37°C for 1 hr. The strip is then removed from the tube and washed with post-coating solution. The strip is then incubated for 15 min at room temperature in goat anti-human Ig reagent labeled with horse radish peroxidase diluted 1:500 in post-coating solution. After incubation in the labeled antibody, the strip is washed serially with PBS, 1% Triton, and distilled water. The strips are developed by incubating them in substrate solution (see 23 above) for 15 min at room temperature.

Positive samples will cause a visually perceptible color change at the spotting site. Normal (negative) sera sample yield no color change or give a faint signal that is discernible from a positive signal. Competition assays may be run on sera giving faint signals to verify that they are negative. In the competition assay, polypeptide (10-25 µg/ml) is added to the test sample and incubated for 1 hr at 37°C before the strip is incubated in the sample. With authentic positive sera the signal is completely blocked by the added polypeptide, whereas with normal (negative) sera there is no change in signal.

Samples of organisms that express the above-described ARV-2 p25 gag and ARV-2 env polypeptides and the fusion protein of ARV-2 p31 and SOD were deposited at the American Type Culture Collection (ATCC), 12301 Parklawn Drive, Rockville, Maryland under the provisions of the Budapest Treaty. The accession numbers and dates of these deposits are listed below.

Expression Product	ATCC Accession No.	Deposit Date
ARV-2 p25 gag	53246	27 August 1985
ARV-2 env	20769	27 August 1985
ARV-2 p31/SOD	20768	27 August 1985

#### Claims

1. A recombinant DNA construct useful for the expression of a recombinant polypeptide in a cell containing the construct, the construct comprising control sequences which regulate transcription and translation of the recombinant polypeptide in the cell and a coding sequence regulated by the control sequences, wherein the coding sequence comprises a DNA sequence of at least about 21 bp in reading frame characterised in that the DNA sequence encodes an antigenic HIV-I amino acid

sequence of Figure 2 which sequence is immunologically non-cross-reactive with HTLV-I and HTLV-II and is reactive with HIV-I.

2. A recombinant DNA construct according to claim 1, which is useful for expression in a eucaryotic cell.
3. A recombinant DNA construct according to claim 1, which is useful for expression in a yeast cell.
4. A recombinant DNA construct according to claim 1 which is useful for expression in a bacterial cell.
5. A recombinant DNA construct according to any one of claims 1 to 4, characterized in that the DNA sequence encodes an amino acid sequence from an env polypeptide of HIV-I.
6. A recombinant DNA construct according to claim 5, wherein the DNA sequence encodes a complete env polypeptide.
7. A recombinant DNA construct according to any one of claims 1 to 4, characterised in that the DNA sequence encodes an amino acid sequence from a gag polypeptide of HIV-I.
8. A recombinant DNA construct according to claim 7, wherein the DNA sequence encodes a complete gag polypeptide.
9. A recombinant DNA construct according to any one of claims 1 to 4, characterised in that the DNA sequence encodes an amino sequence from a pol polypeptide of HIV-I.
10. A recombinant DNA construct according to claim 9, wherein the DNA sequence encodes a complete pol polypeptide.
11. A cell comprising a recombinant DNA construct according to any one of claims 1 to 10, wherein the cell expresses the antigenic HIV-I amino acid sequence and is free from other cells which do not express the antigenic HIV-I amino acid sequence.
12. A cell according to claim 11, wherein the recombinant DNA construct comprises a replication system recognised by the cell.
13. A cell according to claim 12 wherein the cell is eukaryotic.
14. A cell according to any one of claims 11 to 13, which is a yeast.
15. A method of producing a recombinant polypeptide comprising an antigenic HIV-I amino acid sequence wherein a population of cells according to claim 11 is cultured under conditions whereby the recombinant polypeptide is expressed.
16. A method according to claim 15, wherein the cells are eukaryotic.
17. A method according to claim 15, wherein the cells are yeast or bacteria.
18. An immunoassay for detecting antibodies to HIV-I in a sample suspected of containing the antibodies, characterised in that at least one recombinant polypeptide is used to bind the antibodies and the recombinant polypeptide comprises an antigenic env, gag or pol HIV-I amino acid sequence contained in the sequence shown in Figure 2, which polypeptide is immunologically non-cross-reactive with HTLV-I and HTLV-II.
19. An immunoassay according to claim 18, wherein at least one env amino acid sequence and one gag amino acid sequence are used to bind the antibodies.
20. An immunoassay according to claim 19, wherein at least one pol amino acid sequence is also used to bind the antibodies.



21. A diagnostic reagent, immunogen or vaccine capable of binding an anti-HIV-I antibody in human serum characterised in that said reagent, immunogen or vaccine consists of an antigen comprising an immunogenic fragment of at least seven amino acids of an HIV-I env, gag or pol polypeptide, which fragment is immunologically non-cross-reactive with HTLV-I and HTLV-II and which has a sequence contained in the sequence shown in Figure 2.
22. A recombinant polypeptide characterised in that it is produced by a cell transformed by a recombinant DNA construct according to claim 5.
23. A recombinant polypeptide characterised in that it is produced by a cell transformed by a recombinant DNA construct according to claim 6.
24. A recombinant polypeptide characterised in that it is produced by a cell transformed by a recombinant DNA construct according to claim 7.
25. A recombinant polypeptide according to claim 24, wherein the gag amino acid sequence comprises p16 gag.
26. A recombinant polypeptide according to claim 24, wherein the gag amino acid sequence comprises p25 gag.
27. A recombinant polypeptide according to claim 24, wherein the gag amino acid sequence comprises a fusion protein of p16 gag and p25 gag amino acid sequences.
28. A recombinant polypeptide characterised in that it is produced by a cell transformed by a recombinant DNA construct according to claim 10.
29. A recombinant polypeptide according to claim 28, wherein the pol amino acid sequence comprises p31 pol.
30. A recombinant polypeptide according to claim 28, wherein the pol amino acid sequence comprises a fusion protein of superoxide dismutase and p31 pol amino acid sequences.
31. An article of manufacture for use in an immunoassay for HIV-I antibodies characterised in that it comprises a solid support having bound thereto a recombinant polypeptide according to claim 22.
32. An article of manufacture for use in an immunoassay for HIV-I antibodies characterised in that it comprises a solid support having bound thereto recombinant polypeptide according to claim 24.
33. An article of manufacture for use in an immunoassay for HIV-I antibodies characterised in that it comprises a solid support having bound thereto a recombinant polypeptide according to claim 28.
34. A DNA sequence encoding a HIV-I polypeptide derived from a phage selected from ARV-2 (7D) (ATCC No. 40143), ARV-2 (8A) (ATCC No. 40144), and ARV-2 (9B) (ATCC No. 40158).
35. A recombinant DNA construct capable of expressing an antigenic recombinant HIV-I polypeptide derived from an organism selected from ATCC No. 53246, ATCC No. 20769 and ATCC No. 20768.
36. An isolated polynucleotide comprising the ARV-2 sequence of Figure 2 or a fragment of at least 21 bp thereof, provided that said fragment of at least 21 bp is not
  - i) a 3.5 kb viral insert from HTLV-III recombinant clone BH5,
  - ii) a 5.5 kb viral insert from HTLV-III recombinant clone BH8, or
  - iii) a 9.0 kb viral insert from HTLV-III recombinant clone BH10
 disclosed in published European patent application EP-A1-0173529 further provided that said fragment of at least 21 bp is not
  - a) a 0.6 kbp viral insert from LAV designated LAV75,
  - b) a 0.8 kbp viral insert from LAV designated LAV82,
  - c) a 2.5 kbp viral insert from LAV designated LAV13,

- d) a 9.1 to 9.2 kbp viral insert from phage  $\lambda$ J19,
- e) a DNA fragment extending from KpnI (6100) to approximately BamHI (8150) of  $\lambda$ J19,
- f) a DNA fragment extending from approximately KpnI (3500) to approximately BglIII (6500) of  $\lambda$ J19,  
or
- 5 g) a DNA fragment extending from approximately Pst(800) to approximately KpnI(3500) of  $\lambda$ J19  
disclosed in published European patent application EP-A1-0178978  
further provided that said fragment of at least 21 bp is not  
I a 2.3 kbp KpnI-KpnI fragment,  
II a 1.0 kbp EcoRI-EcoRI fragment, or  
10 III a 2.4 kbp EcoRI-HindIII fragment  
disclosed in published European patent application EP-A2-0185444.

#### Patentansprüche

- 15 1. Rekombinantes DNA-Konstrukt zur Expression eines rekombinanten Polypeptids in einer das Konstrukt  
enthaltenden Zelle, wobei das Konstrukt Kontrollsequenzen umfaßt, die die Transkription und die  
Translation des rekombinanten Polypeptids in der Zelle regulieren und eine von den Kontrollsequenzen  
regulierte codierende Sequenz, wobei die codierende Sequenz eine DNA-Sequenz von mindestens  
etwa 21 bp im Leserahmen umfaßt, dadurch gekennzeichnet, daß die DNA-Sequenz eine gegen HIV-I  
20 antigene Aminosäuresequenz von Fig. 2 codiert, wobei die Sequenz mit HTLV-I und HTLV-II immunolo-  
gisch nicht kreuzreaktiv und mit HIV-I reaktiv ist.
- 2. Rekombinantes DNA-Konstrukt nach Anspruch 1 zur Expression in einer eukaryontischen Zelle.
- 25 3. Rekombinantes DNA-Konstrukt nach Anspruch 1 zur Expression in einer Hefezelle.
- 4. Rekombinantes DNA-Konstrukt nach Anspruch 1 zur Expression in einer bakteriellen Zelle.
- 5. Rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die  
30 DNA-Sequenz eine Aminosäuresequenz eines env-Polypeptids von HIV-I codiert.
- 6. Rekombinantes DNA-Konstrukt nach Anspruch 4, wobei die DNA-Sequenz ein komplettes env-Polypep-  
tid codiert.
- 35 7. Rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die  
DNA-Sequenz eine Aminosäuresequenz von einem gag-Polypeptid von HIV-I codiert.
- 8. Rekombinantes DNA-Konstrukt nach Anspruch 7, wobei die DNA-Sequenz ein komplettes gag-Polypep-  
tid codiert.
- 40 9. Rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die  
DNA-Sequenz eine Aminosäuresequenz eines pol-Polypeptids von HIV-I codiert.
- 10. Rekombinantes DNA-Konstrukt nach Anspruch 9, wobei die DNA-Sequenz ein komplettes pol-Polypep-  
45 tid codiert.
- 11. Zelle, die ein rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 10 enthält, wobei die  
Zelle die gegen HIV-I antigene Aminosäuresequenz exprimiert und frei von anderen Zellen ist, die die  
gegen HIV-I antigene Aminosäuresequenz nicht exprimieren.
- 50 12. Zelle nach Anspruch 11, wobei das rekombinante DNA-Konstrukt ein von der Zelle erkanntes Replika-  
tionssystem umfaßt.
- 13. Zelle nach Anspruch 12, wobei die Zelle eukaryontisch ist.
- 55 14. Zelle nach einem der Ansprüche 11 bis 13, wobei die Zelle eine Hefe ist.

15. Verfahren zur Herstellung eines rekombinanten Polypeptids, das eine gegen HIV-I antigene Aminosäuresequenz umfaßt, wobei eine Population von Zellen nach Anspruch 11 unter Bedingungen gezüchtet wird, unter denen das rekombinante Polypeptid exprimiert wird.
- 5 16. Verfahren nach Anspruch 15, wobei die Zellen eukaryontisch sind.
17. Verfahren nach Anspruch 15, wobei die Zellen Hefe oder Bakterien sind.
18. Immunassay zum Nachweis von Antikörpern gegen HIV-I in einer Probe, von der angenommen wird,  
10 daß sie die Antikörper enthält, dadurch gekennzeichnet, daß mindestens ein rekombinantes Polypeptid zur Bindung der Antikörper verwendet wird und das rekombinante Polypeptid eine antigene env-, gag- oder pol-HIV-I Aminosäuresequenz umfaßt, die in der in Figur 2 gezeigten Sequenz enthalten ist, wobei das Polypeptid mit HTLV-I und HTLV-II immunologisch nicht kreuzreaktiv ist.
- 15 19. Immunassay nach Anspruch 18, wobei mindestens eine env-Aminosäuresequenz und eine gag-Aminosäuresequenz zur Bindung der Antikörper verwendet werden.
20. Immunassay nach Anspruch 19, wobei mindestens eine pol-Aminosäuresequenz zur Bindung der Antikörper zusätzlich verwendet wird.
- 20 21. Diagnostisches Reagenz, Immunogen oder Impfstoff, fähig zur Bindung eines anti-HIV-I-Antikörpers in menschlichem Serum, dadurch gekennzeichnet, daß das Reagenz, Immunogen oder der Impfstoff aus einem Antigen besteht, das ein immunogenes Fragment von mindestens sieben Aminosäuren eines HIV-I env-, gag- oder pol-Polypeptids umfaßt, wobei das Fragment mit HTLV-I und HTLV-II immunologisch nicht kreuzreaktiv ist und einen der in Fig. 2 gezeigten Sequenzen enthaltene Sequenz besitzt.
- 25 22. Rekombinantes Polypeptid, dadurch gekennzeichnet, daß es von einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 5 transformiert ist.
- 30 23. Rekombinantes Polypeptid, dadurch gekennzeichnet, daß es von einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 6 transformiert ist.
24. Rekombinantes Polypeptid, dadurch gekennzeichnet, daß es von einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 7 transformiert ist.
- 35 25. Rekombinantes Polypeptid nach Anspruch 24, wobei die gag-Aminosäuresequenz p16 gag umfaßt.
26. Rekombinantes Polypeptid nach Anspruch 24, wobei die gag-Aminosäuresequenz p25 gag umfaßt.
- 40 27. Rekombinantes Polypeptid nach Anspruch 24, wobei die gag-Aminosäuresequenz ein Fusionsprotein aus p16 gag und p25 gag Aminosäuresequenzen umfaßt.
28. Rekombinantes Polypeptid, dadurch gekennzeichnet, daß es in einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 10 transformiert ist.
- 45 29. Rekombinantes Polypeptid nach Anspruch 28, wobei die pol-Aminosäuresequenz p31 pol umfaßt.
30. Rekombinantes Polypeptid nach Anspruch 28, wobei die pol-Aminosäuresequenz ein Fusionsprotein aus Superoxiddismutase und der p31 pol-Aminosäuresequenz umfaßt.
- 50 31. Erzeugnis zur Verwendung in einem Immunassay für HIV-I-Antikörper, dadurch gekennzeichnet, daß es eine feste Unterlage umfaßt, an die ein rekombinantes Polypeptid nach Anspruch 22 gebunden ist.
32. Erzeugnis zur Verwendung in einem Immunassay für HIV-I-Antikörper, dadurch gekennzeichnet, daß es  
55 eine feste Unterlage umfaßt, an die ein rekombinantes Polypeptid nach Anspruch 24 gebunden ist.
33. Erzeugnis zur Verwendung in einem Immunassay für HIV-I-Antikörper, dadurch gekennzeichnet, daß es eine feste Unterlage umfaßt, an die ein rekombinantes Polypeptid nach Anspruch 28 gebunden ist.

34. DNA-Sequenz, die ein HIV-I-Polypeptid codiert und von dem Phagen ARV-2 (7D) (ATCC Nr. 40143), ARV-2' (8A) (ATCC Nr. 40144) oder ARV-2 (9B) (ATCC Nr. 40158) stammt.
35. Rekombinantes DNA-Konstrukt fähig zur Expression eines antigenen rekombinanten HIV-I-Polypeptids,  
5 das aus einem Organismus mit der ATCC Nr. 53246, ATCC Nr. 20769 oder ATCC Nr. 20768 stammt.
36. Isoliertes Polynucleotid, das die ARV-2-Sequenz aus Figur 2 oder ein Fragment mit mindestens 21 bp davon umfaßt, vorausgesetzt, daß das Fragment mit mindestens 21 bp nicht ist
  - i) eine virale 3,5 kb Insertion aus dem rekombinanten HTLV-III Clon BH5,
  - 10 ii) eine virale 5,5 kb Insertion aus dem rekombinanten HTLV-III Clon BH8, oder
  - iii) eine virale 9,0 kb Insertion aus dem rekombinanten HTLV-III Clon BH10,offenbart in der veröffentlichten europäischen Patentanmeldung EP-A1 0 173 529  
ferner vorausgesetzt, daß das Fragment mit mindestens 21 bp nicht ist
  - a) eine virale 0,6 kbp Insertion aus mit LAV75 bezeichnetem LAV,
  - 15 b) eine virale 0,8 kbp Insertion aus mit LAV82 bezeichnetem LAV,
  - c) eine virale 2,5 kbp Insertion aus mit LAV13 bezeichnetem LAV,
  - d) eine virale 9,1 bis 9,2 kbp Insertion aus dem Phagen  $\lambda$ J19,
  - e) ein sich von KpnI (6100) bis ungefähr BamHI (8150) von  $\lambda$ J19 erstreckendes DNA-Fragment,
  - f) ein sich von ungefähr KpnI (3500) bis ungefähr BglII (6500) von  $\lambda$ J19 erstreckendes DNA-  
20 Fragment, oder
  - g) ein sich von ungefähr PstI (800) bis ungefähr KpnI (3500) von  $\lambda$ J19 erstreckendes DNA-Fragment  
offenbart in der europäischen Patentanmeldung EP-A1-0 178 978  
ferner vorausgesetzt, daß das Fragment mit mindestens 21 bp nicht ist
    - I ein 2,3 kbp KpnI-KpnI-Fragment,
    - 25 II ein 1,0 kbp EcoRI-EcoRI-Fragment, oder
    - III ein 2,4 kbp EcoRI-HindIII-Fragment,offenbart in der veröffentlichten europäischen Patentanmeldung EP-A2-0 185 444.

#### Revendications

- 30 1. Produit d'assemblage d'ADN recombinant, utile pour l'expression d'un polypeptide recombinant dans une cellule contenant le produit d'assemblage, le produit d'assemblage comprenant des séquences régulatrices qui règlent la transcription et la traduction du polypeptide recombinant dans la cellule et une séquence codante régulée par les séquences régulatrices, dans lequel la séquence codante  
35 comprend une séquence d'ADN d'au moins environ 21 pb dans le cadre de lecture, caractérisé en ce que la séquence d'ADN code pour une séquence d'acides aminés antigénique du HIV-I de la figure 2, laquelle séquence est immunologiquement non réactive en réaction croisée avec le HTLV-I et le HTLV-II et est réactive avec le HIV-I.
- 40 2. Produit d'assemblage d'ADN recombinant selon la revendication 1, qui est utilisable pour l'expression dans une cellule eucaryote.
3. Produit d'assemblage d'ADN recombinant selon la revendication 1, qui est utilisable pour l'expression dans une cellule de levure.
- 45 4. Produit d'assemblage d'ADN recombinant selon la revendication 1, qui est utilisable pour l'expression dans une cellule bactérienne.
- 50 5. Produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 4, caractérisé en ce que la séquence d'ADN code pour une séquence d'acides aminés provenant d'un polypeptide env de HIV-I.
6. Produit d'assemblage d'ADN recombinant selon la revendication 4, dans lequel la séquence d'ADN code pour un polypeptide env complet.
- 55 7. Produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 4, caractérisé en ce que la séquence d'ADN code pour une séquence d'acides aminés provenant d'un polypeptide gag de HIV-I.

8. Produit d'assemblage d'ADN recombinant selon la revendication 7, dans lequel la séquence d'ADN code pour un polypeptide gag complet.
9. Produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 4, caractérisé en ce que la séquence d'ADN code pour une séquence d'acides aminés provenant d'un polypeptide pol de HIV-I.
10. Produit d'assemblage d'ADN recombinant selon la revendication 9, dans lequel la séquence d'ADN code pour un polypeptide pol complet.
11. Cellule comprenant un produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 10, dans laquelle la cellule exprime la séquence antigénique d'acides aminés du HIV-I et est séparée d'autres cellules qui n'expriment pas la séquence antigénique d'acides aminés du HIV-I.
12. Cellule selon la revendication 11, dans laquelle le produit d'assemblage d'ADN recombinant comprend un système de répllication reconnu par la cellule.
13. Cellule selon la revendication 12, caractérisée en ce que la cellule est eucaryote.
14. Cellule selon l'une quelconque des revendications 11 à 13, qui est une levure.
15. Procédé de production d'un polypeptide recombinant comprenant une séquence antigénique d'acides aminés du HIV-I, dans lequel on cultive une population de cellules selon la revendication 11, dans des conditions dans lesquelles le polypeptide recombinant est exprimé.
16. Procédé selon la revendication 15, dans lequel les cellules sont eucaryotes.
17. Procédé selon la revendication 15, dans lequel les cellules sont des bactéries ou des levures.
18. Essai immunologique pour la détection d'anticorps contre le HIV-I dans un échantillon présumé contenir les anticorps, caractérisé en ce qu'au moins un polypeptide recombinant est utilisé pour fixer les anticorps et le polypeptide recombinant comprend une séquence antigénique d'acides aminés env, gag ou pol du HIV-I contenue dans la séquence représentée sur la figure 2, lequel polypeptide est immunologiquement non réactif en réaction croisée avec le HTLV-I et le HTLV-II.
19. Essai immunologique selon la revendication 18, dans lequel au moins une séquence d'acides aminés env et une séquence d'acides aminés gag sont utilisées pour fixer les anticorps.
20. Essai immunologique selon la revendication 19, dans lequel au moins une séquence d'acides aminés pol est également utilisée pour fixer les anticorps.
21. Réactif de diagnostic, immunogène ou vaccin capable de fixer un anticorps anti-HIV-I dans du sérum humain, caractérisé en ce que ledit réactif consiste en un antigène comprenant un fragment immunogène d'au moins sept acides aminés d'un polypeptide env, gag ou pol du HIV-I, lequel fragment est immunologiquement non réactif en réaction croisée avec le HTLV-I et le HTLV-II et qui présente une séquence contenue dans celle représentée à la Figure 2.
22. Polypeptide recombinant, caractérisé en ce qu'il est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 5.
23. Polypeptide recombinant, caractérisé en ce qu'il est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 6.
24. Polypeptide recombinant, caractérisé en ce qu'il est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 7.
25. Polypeptide recombinant selon la revendication 24, dans lequel la séquence d'acides aminés gag comprend gag-p16.

26. Polypeptide recombinant selon la revendication 24, dans lequel la séquence d'acides aminés comprend gag-p25.
27. Polypeptide recombinant selon la revendication 24, dans lequel la séquence d'acides aminés gag comprend une protéine de fusion de séquences d'acides aminés gag-p16 et gag-p25.
28. Polypeptide recombinant, caractérisé en ce qu'il est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 10.
29. Polypeptide recombinant selon la revendication 28, dans lequel la séquence d'acides aminés pol comprend pol-p31.
30. Polypeptide recombinant selon la revendication 28, dans lequel la séquence d'acides aminés pol comprend une protéine de fusion de séquences d'acides aminés pol-p31 et de la superoxyde dismutase.
31. Article de fabrication pour utilisation dans un essai immunologique pour la détection d'anticorps contre le HIV-I, caractérisé en ce qu'il comprend un support solide sur lequel est fixé un polypeptide recombinant selon la revendication 22.
32. Article de fabrication pour utilisation dans un essai immunologique pour la détection d'anticorps contre le HIV-I, caractérisé en ce qu'il comprend un support solide sur lequel est fixé un polypeptide recombinant selon la revendication 24.
33. Article de fabrication pour utilisation dans un essai immunologique pour la détection d'anticorps contre le HIV-I, caractérisé en ce qu'il comprend un support solide sur lequel est fixé un polypeptide recombinant selon la revendication 28.
34. Séquence d'ADN codant pour un polypeptide de HIV-I dérivé d'un phage choisi parmi ARV-2 (7D) (ATCC n° 40143), ARV-2 (8A) (ATCC n° 40144) et ARV-2 (9B) (ATCC n° 40158).
35. Produit d'assemblage d'ADN recombinant, capable d'exprimer un polypeptide de HIV-I recombinant antigénique, provenant d'un organisme choisi parmi ATCC n° 53246, ATCC n° 20769 et ATCC n° 20768.
36. Polynucléotide isolé comprenant la séquence de ARV-2 de la figure 2 ou un fragment d'au moins 21 pb de celle-ci, étant entendu que ledit fragment d'au moins 21 pb n'est pas
  - I) un segment d'insertion viral de 3,5 kb provenant du clone recombinant BH5 de HTLV-III,
  - II) un segment d'insertion viral de 5,5 kb provenant du clone recombinant BH8 de HTLV-III,
  - III) un segment d'insertion viral de 9,0 kb provenant du clone recombinant BH10 de HTLV-III,
 décrits dans EP-A1-0 173 529,
   
étant en outre entendu que ledit fragment d'au moins 21 pb n'est pas
  - a) un segment d'insertion viral de 0,6 kpb provenant de LAV, dénommé LAV75,
  - b) un segment d'insertion viral de 0,8 kpb provenant de LAV, dénommé LAV82,
  - c) un segment d'insertion viral de 2,5 kpb provenant de LAV, dénommé LAV13,
  - d) un segment d'insertion viral de 9,1 à 9,2 kpb provenant du phage  $\lambda$ J19,
  - e) un fragment d'ADN s'étendant de KpnI (6100) à approximativement BamHI (8150) de  $\lambda$ J19,
  - f) un fragment d'ADN s'étendant d'approximativement KpnI (3500) à approximativement BglIII (6500) de  $\lambda$ J19 ni
  - g) un fragment d'ADN s'étendant d'approximativement PstI (800) à approximativement KpnI (3500) de  $\lambda$ J19
 décrits dans EP-A1-0 178 978,
   
étant en outre entendu que ledit fragment d'au moins 21 pb n'est pas
  - I) un fragment KpnI-KpnI de 2,3 kpb,
  - II) un fragment EcoRI-EcoRI de 1,0 kpb ni
  - III) un fragment EcoRI-HindIII de 2,4 kpb
 décrits dans EP-A2-0 185 444.

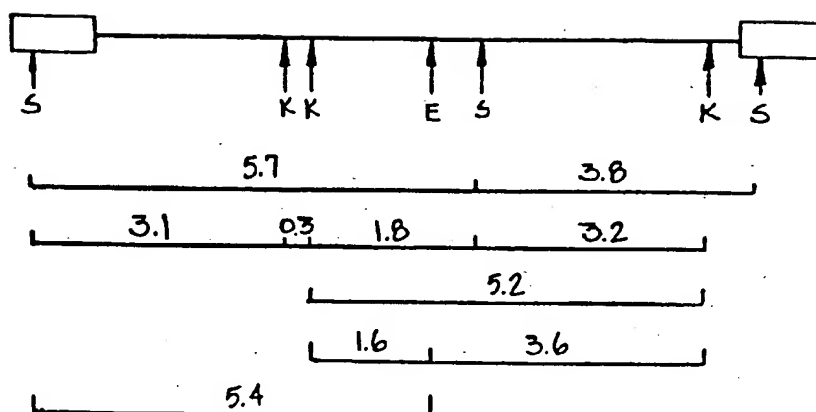


FIG. 1

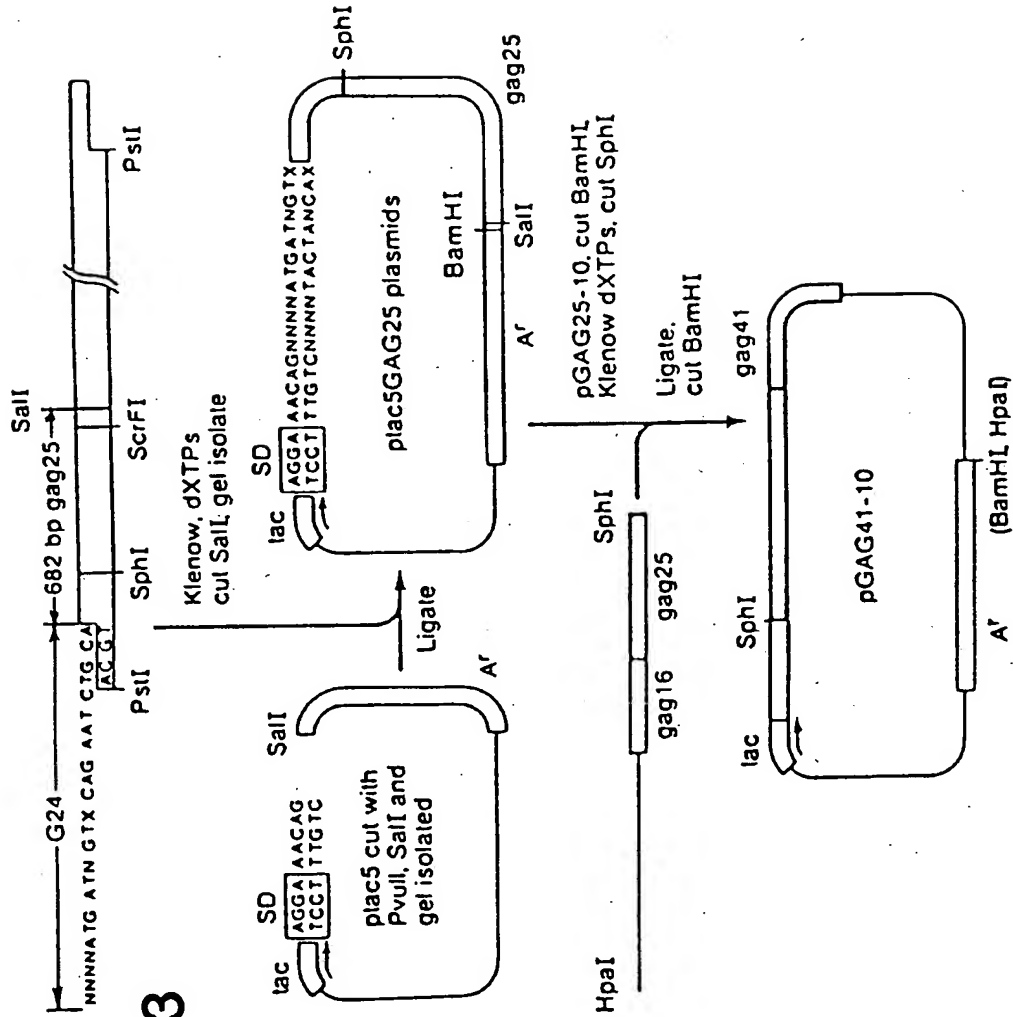
P  
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**FIG. 2-1**



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T  
R

33



**FIG. 4**

[illegible]

**FIG. 5**

[illegible]

**FIG. 6** ARV GAG p16 - synthetic Parts A and B

5' MetGlnArgGlyAsnPheArg<sup>3'</sup>AsnGlnArgLysThrValLysCysPheAsnCysGlyLys  
TATTATGCAAGAGGTAACITTCAGGAAICAAAGAAAGACCGTTAAGTGTTCACACTGTGGTAAG  
RTATACGTTTCTCCATTGAAGTCT<sup>5'</sup>AGTTTCTTCTGGCAATTACAAAGTTGACACCATTC  
3' 10 mnl1, 23 hln11,  
63 GluGlyHisIleAlaLysAsnCysArgAlaProArgLysLysAlaCysTCDArgCysGly  
GAAGGTCACATCGCTAAGAACTGTAGAGCTCCAAGAAAGAGGCTTGTGAGATGTGGY  
CTTCCAGTGTAGCGATTCTTGACATCTCGAGGTTCTTCTTCCGAACAAACCTCTACACCA  
76 dde1, 88 ban2 hglA hglJ11 sao1 sdu1, 89 alu1,  
123 ArgGluGlyHisGlnMetLysAspCysThrGluArgGlnAlaAsnPheLysIle  
AGAGAAGGTCACCAAAATGAAGGACTGTACCGAAAGACAAGCTAACTTCTTGGGTAAAGATC  
TCTCTTCCAGTGGTTACTTCTGACATGGCTTCTGTTCGATTGAAGAACCCATTCTAG  
129 bstE2, 131 hph, 148 rsa1, 161 alu1, 178 bgl11 xho2, 179  
sau3a,  
183 TcPProSerTylYsGlyArgProGlyAsnPheLysGlnSerArgProGluProThrAla  
TGCCCATCTTACAGGGTAGACCCAGGTAACTTCTTGCAATCCAGACCAGAACCAACCGCT  
ACCGGTAGAAATGTTCCCATCTGGTCCATTGAAGAACGTTAGGTCGTGGTCTTGGTTGGCGA  
183 ball ofr1 hae1, 184 hae111, 199 acc1, 204 apy1 ecor11 so  
rf1,  
243 ProProGluGluSerPheArgPheGlyGluGluLysThrThrProSerGlnLysGlnGlu  
CCACCTGAAGAAAGTTTCAGGTTCCGTTGGAAGAAAGAACCCCATCTCAAAAGCAAGAA  
GGTGGACTTCTTCAAAGTCCAAGCCACTTCTTCTGGTGGGTAGAGTTTTCGTTCTT  
249 mbo11, 267 hph, 270 mbo11,  
303 ProIleAspLysGluLeuTyrProLeuThrSerLeuArgSerLeuPheGlyAsnAspPro  
CCAATCGACAAGGAATTGTACCCATTGACCTCTTTGAGATCCCTTGTTCGGTAACGATCCC  
GGTTAGCTGTTCTTAACTATGGGTAACTGGAGAAACCTAGGAACAAGCCATTGTCTAGGG  
307 taq1, 320 rsa1, 331 mnl1, 339 xho2, 340 sau3a, 357 sau3a  
363 SerSerGlnOP AM  
TCGAGCCCAATGATAG  
AGCTCGGTTACTATCAGCT  
363 taq1, 377 acc1 hind11 sal1

MotSerArgIleAspSerAlaThrGluLysLeuIrpValThrValIyrIyrGlyValProVal 51  
 ATBTCTAGGATCGATGTAGTCTACAGAAAAATTTGGGTGCACAGTTTATATGAGTACCTGTG  
 TrpLysGluAlaThrThrLeuPheCysAlaSerAspAlaArgAlaIyrAspThrGluValMisaValIrpAlaThrHisAlaCysValProThrAspProAsnProGlnGluVal 91  
 TGGAAAGACCACTACCACCTCTATTTTGTGATCATGCTAGCAGTATGATACAGAGTACATAATGTTTGGGCCACACATCECTGTGTACCCACAGACCCCAACCCACACAGAACTA  
 ValLysGlyAsnValThrGluAsnPheAsnMetTrpLysAsnAsnMetValGluGlnMetGlnGluAspIleIleSerLeuIrpAspGlnSerLeuLysProCysValLysLeuThrPro 131  
 GTATTGGGAAATGTACAGAAAAATTTAACATGTGGAAAAATACATGTGTAGACACATGTGTAGACAGGATATAATCACTTATGGGATCAAGCCTAAGGCCATGTGTAAATTAACCCCA  
 LeuCysValThrLeuAsnCysThrAspLeuGlyLysAlaThrAsnThrAsnSerSerAsnTrpLysGluGluIleLysGluGluIleLysAsnCysSerPheAsnIleThrThrSerIle 171  
 CTCGTGTACTTTAAATTGCATGATTGGGGAAGCTACTAATACCAATAGTAGTAATTTGGAAAGAGAAATAAAAGGAAATAAAAAACTGCTCTTTCAATATCACCACAGCAT  
 ArgAspLysIleGlnLysGluAsnAlaLeuPheArgAsnLeuAspValIleProIleAspAsnAlaSerThrThrThrAsnIyrArgLeuIleHisCysAsnArgSerVal 211  
 AGAGATAAGATTACAGAAAGAAATGCACCTTTTCTGTAACCTTGATGTAGTACCAATAGATATGCTAGTACTACTACCACTATACCACTATAGTTGATACATTTGTACAGATCAGTC  
 IleThrGlnAlaCysProLysValSerPheGluProIleProIleHisIyrCysThrProIleGluPheAlaIleLeuLysCysAsnAsnLysThrPheAsnGlyLysGlyProCysThr 251  
 ATTACACAGCCCTGCCAAAGGTATCATTTGAGCCCAATTGCCATACATTTGTTACCCCGCTGGTTTTCGATTCCTAAAGTGTAAATATAAACCTTCAATGGAAAAGGCCATGTACA  
 AsnValSerThrValGlnCysThrHisGlyIleArgProIleValSerThrGlnLeuLeuLysGlySerLeuAlaGluGluValIleArgSerAspAsnPheThrAsnAsn 291  
 AATCTCAGCACAGTACATGACATGCAATGGAATTAGGCCAATAGTGTCACTCACTGTAAATGGCAGCTAGCAGAGAGAGGTAGTAAATAGATCTGACATTTCCAGAACAAAT  
 AlLysThrIleIleValGlnLeuAsnGluSerValAlaIleAsnCysThrArgProAsnAsnThrArgLysSerIleIyrIleGlyProGlyArgAlaPheHisThrThrGlyArg 331  
 GCTAAACCAATAATAGTACAGCTGAATCTGTAGCAATTAACCTACAGAGCCCAACAACTACAGAAAAAGTATCTATATAGGACCAGGAGAGCATTTTCATACAGAGGAGAG  
 IleIleGlyAspIleArgLysAlaHisCysAsnIleSerArgAlaGlnTrpAsnAsnThrLeuGluGlnIleValLysLysLeuArgGluGlnPheGlyAsnAsnLysThrIleValPhe 371  
 ATAATAGAGATATAGAAAGCCACATTTGAACATTAGTAGACCAATGCAATTAACCTTTAGAACAGATAGTTTAAAGAAATTAAGAGAACAGTTTGGGAATATAAAGCAATAGTCTTT  
 AsnGlnSerSerGlyGlyAspProGluIleValMetHisSerPheAsnCysArgGlyGlyPhePheIyrCysAsnThrThrGlnLeuPheAsnAsnThrIrpArgLeuAsnHisThrGlu 411  
 AATCAATCTCAGGAGGGGCCAGAAATGTATATGACAGTTTAAATGTAGAGGGGAAATTTTCTACTGTATATACACACAACTGTTTAAATATATACATGAGGTTTAAATCAGACTGAA  
 GlyThrLysGlyAsnAspThrIleIleLeuProCysArgIleLysGlnIleIleAsnMetTrpGlnGluValGlyLysAlaMetIyrAlaProProIleGlyGlyGlnIleSerCysSer 451  
 GGAACCTAAGGAAATCAGACATCATACTCCCATGTAGAAATAAAGCAATATATACATGTGTGAGGAGAGTAAAGCAATGTATGCCCTCCCATTTGGAGAGCAAAATTAGTCTTCA  
 SerAsnIleThrGlyLeuLeuThrArgAspGlyGlyThrAsnValThrAsnAspThrGluValPheArgProGlyGlyGlyValAspMetArgAspAsnTrpArgSerGluLeuIyrLys 491  
 TCAATATTACAGGCTCTATTAAACAGAGATGTGTGTACAAATGTAACTAATGACACCGAGCTCTCAGACCTGGAGGAGAGAGATATGAGGAGCAATTTGGAGAAATGCAATTATATAA  
 TyrLysValIleLysIleGluProAsnSerValSer  
 TATAAGTAATAAAAAATGCAACCAATTCGATATCTTA

E N V

PYK Terminator

FIG. 7

## FIG. 8-1

Nucleotide  
Positions  
Relative to  
Figure 2

MetIleAspLysAlaGlnGluGluHisGluLysTyrHisSerAsnTrp  
1 AGGXAAACAG:::ATGAT:GA:AAGGCACAAGAAACATGAGAAATATCACAGTAATTGG  
TCCXTTGTGTC:::TACTA:CT:TTCCGTGTTCTTCTTGTACTCTTTATAGTGTCAATTAACC  
32 mbo11, 38 nla111,  
3820 62 ArgAlaMetAlaSerAspPheAsnLeuProProValValAlaLysGluIleValAlaSer  
AGAGCCATGGCTAGTGTATTTAACCTGCCACCTGTAGTAGCAAAAGAAATAGTAGCCAGC  
TCTCGGTACCGATCACTAAAATTGGACGGTGGACATCATCGTTTCTTTATCATCGGTCCG  
66 nco1, 67 nla111, 118 nspB11 pvu11, 119 alu1,  
3880 122 CysAspLysCysGlnLeuLysGlyGluAlaMetHisGlyGlnValAspCysSerProGly  
TGIGATAAATGTCAAGTAAAGGAGAGCCATGCATGGACAAGTAGACTGTAGTCCAGGA  
ACACTATTTACAGTCGATTTTCTCTTCCGTACGTACCTGTTTCTCTGACATCAGGTCTCT  
135 alu1, 151 nla111, 152 ns11 ava3, 155 nla111, 164 acc1, 1  
76 apy1 bstX1 ecor11 scrF1,  
3940 182 IleTrpGlnLeuAspCysThrHisLeuGluGlyLysIleIleLeuValAlaValHisVal  
ATATGGCAACTAGATTGTACACATCTAGAAGGAAAAATTATCCTGGTAGCAGTTTCATGTA  
TATACCGTTGATCTAATCATGTGTAGATCTTCTTTTAAATAGGACCATCGTCAAGTACAT  
198 rsal, 205 xba1, 223 apy1 ecor11 scrF1, 236 nla111,  
4000 242 AlaSerGlyTyrIleGluAlaGluValIleProAlaGluThrGlyGlnGluThrAlaTyr  
GCCAGTGGATATATAGAAGCAGAAGTTATTCAGCAGAGACAAGGACAGGAAACAGCATAT  
CGGTACCTATATATCTTCGTCTTCAATAAGGTCGTCTCTGTCCCGTCTTTGTCTGTATA  
263 xmn1,  
4060 302 PheLeuLeuLysLeuAlaGlyArgTrpProValLysThrIleHisThrAspAsnGlySer  
TTTCTCTTAAATTTAGCAGGAAGATGGCCAGTAAAAACAATACATACAGCAATTCGAGC  
AAAGAGAATTTTAATCGTCTTCTACCGGTCAATTTTGTATGTATGTCTGTACCGTCCG  
321 mbo11, 326 bal1 cfr1 hae1, 327 hae111, 357 bbv inu4h1,  
4120 362 AsnPheThrSerThrThrValLysAlaAlaCysTrpTrpAlaGlyIleLysGlnGluPhe  
AATTTCAACAGTACTACGGTTAAGGCCGCTGTGTGGTGGGACAGGGATCAAGACAGGAATTT  
TAAAGTGGTTCATGATGCCAATTCGGCGGACAAACACCCGTCCTAGTCTGTCTTAA  
366 hph, 371 sca1, 372 rsal, 385 hae111, 386 inu4h1 nsb11, 4  
05 bin1, 406 dpn1 sau3a,  
4180 422 GlyIleProTyrAsnProGlnSerGlnGlyValValGluSerMetAsnAsnGluLeuLys  
GGCATTCCCTACAATCCCCAAGTCAAGGAGTAGTAGAATCTATGAATAATGAATTAAG  
CCGTAAGGGATGTTAGGGGTTTCAGTTCCTCATCATCTTAGATACTTATTACTTAATTTT  
423 bsm1, 458 hinf1,  
4240 482 LysIleIleGlyGlnValArgAspGlnAlaGluHisLeuLysThrAlaValGlnMetAla  
AAAATTATAGGACAGGTAAAGATCAGGCTGAACACCTTAAGACAGCAGTACAAATGGCA  
TTTAAATATCCTGTCCATTCTCTAGTCCGACTTGTGGAATTCGTCTGTCTGTCTTACCGT  
503 dpn1 sau3a, 518 afl111, 530 rsal,  
4300 542 ValPheIleHisAsnPheLysArgLysGlyGlyIleGlyGlyTyrSerAlaGlyGluArg  
GTATTCATCCACAATTTTAAAGAAAGGGGGGATTGGGGGATACAGTGCAGGGGAAAGA  
CATAAGTAGGTGTTAAATTTCTTTTCCCCCTAACCCCTATGTACAGTCCCTTTCT  
547 fok1, 557 aha111,  
4360 602 IleValAspIleIleAlaThrAspIleGlnThrLysGluLeuGlnLysGlnIleThrLys  
ATAGTAGACATAATAGCAACAGACATACAACTAAAGAACTACAAAGCAATTAACAAA  
TATCATCTGTATTATCGTTGTCTGTATGTTTGTATTTCTTGATGTTTTCTGTTAATGTTT  
605 acc1,  
4420 662 IleGlnAsnPheArgValTyrTyrArgAspAsnLysAspProLeuTrpLysGlyProAla  
ATTCAAAATTTTCCGGTTTATTTACAGGGACAACAAAGATCCCTTTTGAAAGGACAGCA  
TAAGTTTAAAGCCCAATTAATGTCCCTGTTGTTCTAGGGGAAACCTTTCTGTTGCT  
697 xho2, 698 dpn1 sau3a, 713 asu1 ava2,

4480	722	<p>           LysLeuLeuIcPLysGlyGluGlyAlaValValIleGlnAspAsnSerAspIleLysVal            AAGCTTCTCTGGAAAGGTGAAGGGGCCAGTAGTAATACAAGATAATAGTGACATAAAGTA            TTCGAAGAGAGACCTTCCACTTCCCCGTCATCATTAATGTTCTATTATCACTGTATTTTCAT            722 hind111, 723 alu1, 737 hph,         </p>
4540	782	<p>           ValProArgArgLysAlaLysIleIleArgAspIYcGlyLysGlnMetAlaGlyAspAsp            GTGCCAAGAAAGAAAGCCAAATAATCATTCAGGGATTTTGGAACTTACAGATGGCCGGTCAATGAT            CACGGTTCTTCTTTCTGTTTTTAGTAATCCCTAATAACCTTTGTCTACCGTCCACTACTA            789 mbo11, 833 hph,         </p>
4600	842	<p>           CysValAlaSerArgGlnAspGluAspAm            TGTGTGGCAAGTAGACAGGATGAGGATTAGTCGACGGAACTTTTAGTAAACACACC            ACACACCGTTCACTCTGTCTACTCCCTAATCAGCTGCCCTAAGAAATCATTTTGTGG            852 acc1, 859 fok1, 863 mnl1, 871 acc1 hind11 sal1, 872 taq1            , 878 ecor1,         </p>

FIG. 8-2



(19)



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(54) **Recombinant proteins of viruses associated with lymphadenopathy syndrome and/or acquired immune deficiency syndrome**

Rekombinante Virusproteine begleitet von lymphadenopathischem Syndrom und/oder "Acquired Immune Deficiency Syndrome" (AIDS)

Protéines recombinantes de virus associées avec le syndrome lymphadénopathique et/ou le syndrome d'immuno-déficience acquise (SIDA)

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**EP 0 181 150 B2**

## Description

[0001] This invention is in the field of genetic engineering. More particularly, it relates to recombinant viral proteins associated with lymphadenopathy syndrome and/or acquired immune deficiency syndrome.

5 [0002] With the discovery of human T-cell lymphotropic Virus-I (HTLV-I) as an infectious agent in humans, it was established that retroviruses could infect humans and could be the etiological agent of disease. After HTLV-I was established, a second retrovirus of the same family, HTLV-II was found in a hairy cell leukemia established strain. Since that time, other human retroviruses have been isolated which are associated with lymphadenopathy syndrome (LAS) and/or acquired immune deficiency syndrome (AIDS) victims. Various retroviruses have been isolated from individuals  
10 with AIDS (sometimes called HTLV-III) or LAS (sometimes called LAV). See for example, Barre-Sinoussi, et al, Science (1983) 220:868-871 and Montagnier, et al, Cold Spring Harbor Symposium (1984) In press; Vilmer, et al, Lancet (1984) 1:753, Popovic, et al, Science - (1984) 224:497 and Gallo, et al, Science (1984) 224:500. A comparison of HTLV-III and LAV may be found in Feorino, et al, (1984), supra. See also, Klatzman, et al, Science (1984) 225:59-62, Montagnier, et al, ibid (1984) 63-66, and the references cited therein for a survey of the field. A general discussion of the T-cell  
15 leukemia viruses may be found in Marx, Science (1984) 22:475-477. Levy, et al, Science (1984) 225:840-842 report the isolation of ARV (AIDS-associated retroviruses).

[0003] At the time of filing this application, these viruses (HTLV-III, LAV, and ARV) were generically referred to as human T-cell lymphotropic retrovirus (hTLR). However, from 1986 onwards the equivalent generic term "human immunodeficiency virus" (HIV) was adopted as the recognised term for such viruses. Subsequently, a sub-division of the  
20 generic group HIV was necessary into HIV-I and HIV-II. Since the application relates to ARV-2 isolates which are HIV-I isolates, HIV-I has been substituted throughout the application for hTLR (HIV) and the claims are accordingly limited to HIV-I. The HIVs (hTLRS) may be shown to be of the same class by being similar in their morphology, serology, reverse transcriptase optima and cytopathology, as identified in the above references. For example, the reverse transcriptase prefers  $Mg^{+2}$ , and has a pH optima of about 7.8.

25 [0004] DNA clones containing HIV sequences are disclosed in EP-A1-0173529, EP-A1-0178978, EP-A2-0185444 and WO 86/02383.

[0005] The present invention is defined in the claims.

[0006] Figure 1 is a restriction map of proviral DNA (ARV-2).

30 [0007] Figure 2 is the nucleotide sequence of ARV-2(9B). The amino acid sequences for the products of the gag, pol, and env genes are indicated. The U3, R, and U5 regions of the LTRs are also designated. The cap site is position +1. A 3 bp inverted repeat at the ends of the LTR, the TATA box at position -29, the sequence complementary to the 3'-end of the tRNA<sup>lys</sup> at position 183, and the polyadenylation signal at position 9174 are underlined. The overlines indicate the amino sequences determined from virion proteins. The nucleotides at the beginning of each line are numbered, and the amino acids at the end of each line are indicated.

35 [0008] Figure 3 is a flow diagram showing the procedures for making the plasmid pGAG25-10.

[0009] Figure 4 is the nucleotide sequence of the p25 gag gene cloned in plasmid pGAG25-10 and the amino acid sequence encoded by that gene.

[0010] Figure 5 is the coding strand of the nucleotide sequence cloned in pGAG41-10 for producing the fusion protein p41 gag and the corresponding amino acid.

40 [0011] Figure 6 is a nucleotide sequence coding for ARV-2 p16 gag protein that was cloned into plasmid pta5 to make an expression plasmid for producing p16 gag protein in bacteria.

[0012] Figure 7 is a nucleotide sequence that encodes ARV-2 env protein that was used to prepare plasmid pDPC303.

45 [0013] The HIV-I DNA sequences, either isolated and cloned from proviral DNA or cDNA or synthesized, may be used for expression of polypeptides which may be a precursor protein subject to further manipulation by cleavage, or a complete mature protein or fragment thereof. The smallest sequence of interest, so as to provide a sequence encoding an amino acid sequence capable of specific binding to a receptor, e.g., an immunoglobulin, will be 21 bp, usually at least 45 bp, exclusive of the initiation codon. The sequence may code for any greater portion of or the complete polypeptide, or may include flanking regions of a precursor polypeptide, so as to include portions of sequences or entire sequences coding for two or more different mature polypeptides. The sequence will usually be less than about 5 kbp,  
50 more usually less than about 3 kbp.

55 [0014] Sequences of particular interest having open reading frames (Figure 2) define the structural genes for the gag proteins (p16 and p25) and the env protein. It is to be understood that the above sequences may be spliced to other sequences present in the retrovirus, so that the 5'-end of the sequence may not code for the N-terminal amino acid of the expression product. The splice site may be at the 5'-terminus of the open reading frame or internal to the open reading frame. The initiation codon for the protein may not be the first codon for methionine, but may be the second or third methionine, so that employing the entire sequence indicated above may result in an extended protein. However, for the gag and env genes there will be proteolytic processing in mammalian cells, which processing may include the removal of extra amino acids.

- [0015] In isolating the different domains the provirus may be digested with restriction endonucleases, the fragments electrophoresed and fragments having the proper size and duplexing with a probe, when available, are isolated, cloned in a cloning vector, and excised from the vector. The fragments may then be manipulated for expression, Superfluous nucleotides may be removed from one or both termini using Bal31 digestion. By restriction mapping convenient restriction sites may be located external or internal to the coding region. Primer repair or *in vitro* mutagenesis may be employed for defining a terminus, for insertions, deletion, point or multiple mutations, or the like, where codons may be changed, either cryptic or changing the amino acid, restriction sites introduced or removed, or the like. Where the gene has been truncated, the lost nucleotides may be replaced using an adaptor. Adaptors are particularly useful for joining coding regions to ensure the proper reading frame.
- [0016] The env domain of the HIV-I genome can be obtained by digestion of the provirus with EcoRI and KpnI and purification of a 3300 base pair (bp) fragment, which fragment contains about 400 bp of 5' non-coding and about 200 bp of 3' non-coding region. Three different methionines coded for by the sequence in the 5' end of the open reading frame may serve as translational initiation sites.
- [0017] Digestion of proviral sequences with SacI and EcoRV provides a fragment of about 2300 bp which contains the gag domain and a second small open reading frame towards the 3' end of the gag region. The gag domain is about 1500 bp and codes for a large precursor protein which is processed to yield proteins of about 25,000 (p25), 16,000 (p16) and 12,000 (p12) daltons. Digestion with SacI and BglII may also be used to obtain exclusively the gag domain with p12, p25 and partial p16 regions.
- [0018] The polypeptides which are expressed by the above DNA sequences may find use in a variety of ways. The polypeptides or immunologically active fragments thereof, may find use as diagnostic reagents, being used in labeled or unlabeled form or immobilized (i.e., bound to a solid surface), as vaccines, in the production of monoclonal antibodies, e.g., inhibiting antibodies, or the like.
- [0019] The DNA sequences may be joined with other sequences, such as viruses, e.g., vaccinia virus or adenovirus, to be used for vaccination. Particularly, the DNA sequence of the viral antigen may be inserted into the vaccinia virus at a site where it can be expressed, so as to provide an antigen of HIV-I recognized as an immunogen by the host. The gag or env genes or fragments thereof that encode immunogens can be used.
- [0020] Another alternative is to join the gag or env regions or portions thereof to HBsAg gene or pre-S HBsAg gene or immunogenic portions thereof, which portion is capable of forming particles in a unicellular microorganism host, e.g., yeast or mammalian cells. Thus, particles are formed which will present the HIV-I immunogen to the host in immunogenic form, when the host is vaccinated with assembled particles.
- [0021] As vaccines, the various forms of the immunogen can be administered in a variety of ways, orally, parenterally, intravenously, intra-arterially, subcutaneously, or the like. Usually, these will be provided in a physiologically acceptable vehicle, generally distilled water, phosphate-buffered saline, physiological saline, or the like. Various adjuvants may be included, such as aluminum hydroxide, and the dosages, number of times of administration and manner of administration determined empirically.
- [0022] In order to obtain the HIV-I sequence, virus can be pelleted from the supernatant of an infected host cell. A 9 kb RNA species is purified by electrophoresis of the viral RNA in low-melting agarose gels, followed by phenol extraction. The purified RNA may then be used as a template with random primers in a reverse transcriptase reaction. The resulting cDNA is then screened for hybridization to polyA + RNA from infected and uninfected cells. Hybridization occurring from infected, but not uninfected cells, is related to the HIV-I.
- [0023] Genomic DNA from infected cells can be restriction enzyme digested and used to prepare a bacteriophage library. Based upon restriction analysis of the previously obtained fragments of the retrovirus, the viral genome can be partially digested with EcoRI and 9 kb-15 kb DNA fragments isolated and employed to prepare the library. The resulting recombinant phage may be screened using a double-lift screening method employing the viral cDNA probe, followed by further purification, e.g., plaque-purification and propagation in large liquid cultures. From the library, the complete sequence of the virus can be obtained and detected with the previously described probe.
- [0024] HIV-I DNA (either provirus or cDNA) may be cloned in any convenient vector. Constructs can be prepared, either circular or linear, where the HIV-I DNA, either the entire hTLR or fragments thereof, may be ligated to a replication system functional in a microorganism host, either prokaryotic or eukaryotic cells (mammalian, yeast, arthropod, plant). Micro-organism hosts include E. coli, B. subtilis, P. aeruginosa, S. cerevisiae, N. crassa, etc. Replication systems may be derived from ColE1, 2  $\mu$  plasmid,  $\lambda$ , SV40, bovine papilloma virus, or the like, that is, both plasmids and viruses. Besides the replication system and the HIV-I DNA, the construct will usually also include one or more markers, which allow for selection of transformed or transfected hosts. Markers may include biocide resistance, e.g., resistance to antibiotics, heavy metals, etc., complementation in an auxotrophic host to provide prototrophy, and the like.
- [0025] For expression, expression vectors will be employed. For expression in microorganisms, the expression vector may differ from the cloning vector in having transcriptional and translational initiation and termination regulatory signal sequences and may or may not include a replication system which is functional in the expression host. The coding sequence is inserted between the initiation and termination regulatory signals so as to be under their regulatory control.

Expression vectors may also include the use of regulatable promoters, e.g., temperature-sensitive or inducible by chemicals, or genes which will allow for integration and amplification of the vector and HIV-I DNA such as tk, dhfr, metallothionein, or the like.

**[0026]** The expression vector is introduced into an appropriate host where the regulatory signals are functional in such host. The expression host is grown in an appropriate nutrient medium, whereby the desired polypeptide is produced and isolated from cells or from the medium when the polypeptide is secreted.

**[0027]** Where a host is employed in which the HIV-I transcriptional and translational regulatory signals are functional, then the HIV-I DNA sequence may be manipulated to provide for expression of the desired polypeptide in proper juxtaposition to the regulatory signals.

**[0028]** The polypeptide products can be obtained in substantially pure form, particularly free of debris from human cells, which debris may include such contaminants as proteins, polysaccharides, lipids, nucleic acids, viruses, bacteria, fungi, etc., and combinations thereof. Generally, the polypeptide products will have less than about 0.1, usually less than about 0.01 weight percent, of contaminating materials from the expression host. Depending upon whether the desired polypeptide is produced in the cytoplasm or secreted, the manner of isolation will vary. Where the product is in the cytoplasm, the cells are harvested, lysed, the product extracted and purified, using solvent extraction, chromatography, gel exclusion, electrophoresis, or the like. Where secreted, the desired product will be extracted from the nutrient medium and purified in accordance with the methods described above.

**[0029]** The expression products of the env and gag genes and immunogenic fragments thereof having immunogenic sites may be used for screening antisera from patients' blood to determine whether antibodies are present which bind to HIV-I antigens. One or more of the recombinant antigens are used in the serological assay. Preferred modes of the assay employ a combination of gag, env, and pol antigens. A combination of p25, P31 and env recombinant antigens is particularly preferred. A wide variety of immunoassay techniques can be employed, involving labeled or unlabeled antigens or immobilized antigens. The label may be fluorescers, radionuclides, enzymes, chemiluminescers, magnetic particles, enzyme substrates, cofactors or inhibitors, ligands, or the like.

**[0030]** A particularly convenient technique is to bind the antigen to a support such as the surface of an assay tube or well of an assay plate or a strip of material, such as nitrocellulose or nylon, that binds proteins and contact the sample with the immobilized antigen. After washing the support to remove non-specifically bound antisera, labeled antibodies to human Ig are added. The support is then washed again to remove unbound labeled anti-human Ig. The presence of bound analyte is then determined through detection of the label.

**[0031]** ELISA and "dot-blot" assays are particularly useful for screening blood or serum samples for anti-HIV-1 antibodies. The ELISA assay uses microtiter trays having wells that have been coated with the antigenic HIV-I polypeptides(s). The wells are also typically post-coated with a non-antigenic protein to avoid nonspecific binding of antibodies in the sample to the well surface. The sample is deposited in the wells and incubated therein for a suitable period under conditions favorable to antigen-antibody binding.

**[0032]** Anti-HIV-I antibodies present in the sample will bind to the antigen(s) on the well wall. The sample is then removed and the wells are washed to remove any residual, unbound sample. A reagent containing enzyme labeled antibodies to human immunoglobulin is then deposited in the wells and incubated therein to permit binding between the labeled anti-human Ig antibodies and HIV-I antigen-human antibody complexes bound to the well wall. Upon completion of the incubation, the reagent is removed and the wells washed to remove unbound labeled reagent. A substrate reagent is then added to the wells and incubated therein. Enzymatic activity on the substrate is determined visually or spectrophotometrically and is an indication of the presence and amount of anti-HIV-I antibody-containing immune complex bound to the well surface.

**[0033]** The "dot-blot" procedure involves using hTLR antigen(s) immobilized on a piece or strip of bibulous support material, such as nitrocellulose filter paper or nylon membrane, rather than antigen-coated microtiter trays. The support will also be treated subsequently with a non-antigenic protein to eliminate nonspecific binding of antibody to the support. The antigen-carrying support is dipped into the sample and allowed to incubate therein. Again, any anti-HIV-I antibodies in the sample will bind to the antigen(s) immobilized on the support. After a suitable incubation period the support is withdrawn from the sample and dipped repeatedly in wash buffer to remove any unbound sample from the paper. The support is then dipped into the enzyme-labeled antibody to human Ig reagent for a suitable incubation period. Following treatment with the labeled reagent the support is dipped in wash buffer, followed by incubation in the substrate solution. Enzymatic activity, indicating the presence of anti-HIV-I antibody-containing complexes on the support, causes color changes on the support which may be detected optically.

**[0034]** Either of these techniques may be modified to employ labels other than enzymes. The reading or detection phases will be altered accordingly.

**[0035]** The antigenic polypeptides of HIV-I may also be used as immunogens by themselves or joined to other polypeptides for the production of antisera or monoclonal antibodies which may be used for therapy or diagnosis. The immunoglobulins may be from any mammalian source, e.g., rodent, such as rat or mouse, primate, such as baboon, monkey or human, or the like. For diagnosis, the antibodies can be used in conventional ways to detect HIV-I in a

clinical sample.

**[0036]** The HIV-1 DNA sequences may also be labeled with isotopic or non-isotopic labels or markers and be used as DNA probes to detect the presence of native HIV-1 nucleotide sequences in samples suspected of containing same.

**[0037]** The following examples are offered by way of illustration and not by way of limitation.

#### 1. AIDS related virus-2 (ARV-2) purification and preparation of viral RNA.

**[0038]** HUT-78 cells infected with ARV-2 (ATCC Accession No. CRL 8597, deposited on August 7, 1984) were obtained from Dr. Jay Levy, University of California, San Francisco. Cultures were grown for two weeks in RPMI medium with 10% fetal calf serum. Cultures were centrifuged at 2 Krpm for 1 hr at 4 ° C using a SW-28 rotor. The pellet, containing the virus, was resuspended in 10 mM Tris-HCl, pH 7.5 on ice. The resuspended pellet was treated with 10 µg of DNase (Boehringer-Mannheim) and was layered onto a linear sucrose gradient (15-50% in 10 mM Tris-HCl, pH 7.5, 1 mM EDTA, 20 mM NaCl). The gradient was spun at 34 Krpm for 4 hr at 4°C, in SW-41 rotor. Five 2.5 ml fractions were collected and an aliquot of each was electrophoresed in a 1% agarose, 5 mM-methyl mercury hydroxide gel (Bailey and Davidson, *Anal Biochem* (1976) 70:75-85) to determine which contained the 9 kb viral RNA. The fraction containing the viral RNA was diluted to 10 ml in 10 mM Tris-HCl, pH 7.5, 1 mM EDTA and was centrifuged at 34 Krpm for 2 hr at 4°C. The pellet was resuspended in 20 mM Tris-HCl, pH 7.6, 10 mM EDTA, 0.1% SDS, and 200 µg/ml proteinase K. Incubation was carried out for 15 min at room temperature. The mixture was extracted with phenol and the aqueous phase was made 400 mM NaCl and precipitated with ethanol. The pellet was resuspended in water and stored at -70°C.

**[0039]** To purify the viral RNA from the nucleic acid pellet obtained as described above, a sample was electrophoresed in a low-melting 1% agarose gel containing 5 mM Methyl mercury hydroxide. After electrophoresis, the gel was stained with 0.1% ethidium bromide and nucleic acid bands were visualized under UV light. The region corresponding to 9 kb was cut from the gel and the agarose was melted at 70°C for 2 to 3 min in three volumes of 0.3 M NaCl, 10 mM Tris, pH 7.5, 1 mM EDTA. The mixture was extracted with an equal volume of phenol. The aqueous phase was reextracted with phenol and was precipitated with ethanol. The pellet was washed with cold 95% ethanol, air dried, resuspended in water and stored at -70 °C until use. One hundred ml of culture medium yielded 0.5 to 1 µg of purified RNA.

#### 2. Synthesis of labeled homologous viral probe.

**[0040]** A <sup>32</sup>P-labeled cDNA was made to the gel purified viral RNA using random primers (calf thymus primers) prepared as described in Maniatis, et al, *A Laboratory Manual*, Cold spring Harbor, NY, 1982. The reaction mixture contained 2 µl of 0.5 M MgCl<sub>2</sub>; 5 µl of 0.1 M dithiothreitol; 2.5 µl each of 10 mM dATP, 10 mM dGTP and 10 mM dTTP; 2.5 µl calf thymus primer (100A<sub>260</sub>/ml); 0.5 µg viral RNA; 5 µl of actinomycin D (200 µg/ml); 10 µl of <sup>32</sup>P-dCTP (> 3000 Ci/mmol, 1 mCi/ml) and 1 µl of AMV reverse transcriptase (17 units/µl) in a 50 µl reaction volume. The reaction was incubated for 1 hr at 37°C. The probe was purified away from free nucleotides by gel filtration using a Sephadex® G50 column. The void volume was pooled, NaCl was added to a final concentration of 400 mM and carrier single-stranded DNA to 100 µg/ml, and the cDNA was precipitated with ethanol. The pellet was resuspended in water and incorporated <sup>32</sup>P counts were determined.

#### 3. Detection of ARV sequences in polyA+ RNA prepared from infected HUT-78 cells.

**[0041]** PolyA+ RNA was prepared from HUT-78 cells infected with ARV-2, ARV-3 or ARV-4 (three different isolates from three different AIDS patients) and from uninfected HUT-78 cells. The polyA+ RNA was electrophoresed on 1% agarose gels containing 5 mM methyl mercury hydroxide (Bailey and Davidson, supra), was transferred to nitrocellulose filters, and hybridized with the homologous probe prepared as described in Section 2. Hybridizations were carried out in 50% formamide, 3 x SSC at 42 °C. Washes were at 50 °C in 0.2 x SSC. A 9 kbp band was present in all three samples of infected HUT-78 cells. This band was absent in polyA+ from uninfected cells.

#### 4. Detection of ARV sequences in infected and non-infected HUT-78 cells.

**[0042]** High molecular weight DNA (chromosomal) was prepared from cultures of HUT-78 cells infected with ARV-2 and from non-infected HUT-78 cells following the procedure of Luciw, et al, *Molec and Cell Biol* - (1984) 4:1260-1269. The DNA was digested with restriction enzyme(s), electrophoresed in 1% agarose gels and blotted onto nitrocellulose following the procedure described by Southern, (1975), supra. Blots were hybridized with the <sup>32</sup>P-labeled probe (10<sup>6</sup> cpm/blot) in a mixture containing 50% formamide, 3 x SSC, 10 mM Hepes, pH 7.0, 100 µg/ml denatured carrier DNA, 100 µg/ml yeast RNA and 1 x Denhardt's for 36 hr at 42°C. Filters were washed once at room temperature in 2 x SSC and twice at 42°C in 0.2 x SSC, 0.1% SDS. Filters were air dried and exposed to X-Omat film using an intensifying

screen.

[0043] The homologous  $^{32}\text{P}$ -probe to ARV-2 hybridized specifically to two bands in the DNA from infected cells restricted with SacI. These bands were absent when DNA of non-infected cells was used, indicating that the probe is hybridizing specifically to infected cells presumably to the provirus integrated in the chromosomal DNA. The molecular weight of the bands is approximately 5 kb and 3 kb.

[0044] In order to determine if different enzymes would cut the proviral sequence, several other restriction digestions of the cell DNA were carried out using EcoRI, SphI or KpnI or double digestions using two of them. Southern results show specific bands hybridizing when DNA of infected cells is used. Figure 1 shows a schematic map of the positions of restriction enzyme sites in the proviral sequence, and indicates fragment sites.

#### 5. Cloning of proviral ARV-2 DNA.

[0045] High molecular weight cell DNA from infected HUT-78 cells was prepared following the procedure of Luciw, et al, supra. The DNA was digested with EcoRI, which cuts once in the provirus, centrifuged in a sucrose gradient and fractions corresponding to 8-15 kb were pooled, dialyzed and concentrated by ethanol precipitation. The bacteriophage X derivative cloning vector, EMBL-4 (Karn, et al. Methods Enzymol (1983) 101:3-19) was digested to completion with a mixture of EcoRI, BamHI and Sall restriction enzymes and the DNA then deproteinized by phenol-chloroform extraction, precipitated with cold ethanol and resuspended in ligation buffer. The EMBL-4 phage DNA and EcoRI digest of cellular DNA were mixed and ligated and the resultant recombinant phage genomes packaged in vitro. After phage infection of X-sensitive *E. coli* - (DP50supF), about 500,000 phage plaques were transferred onto nitrocellulose filters, DNA was fixed and the filters were screened with a homologous  $^{32}\text{P}$ -probe prepared as described in Section 2. Eleven recombinant phage out of 500,000 phage annealed in the initial double-lift screening method (Maniatis, et al, Molecular Cloning, A Laboratory Manual, NY, 1982) to viral cDNA probe, and these were further plaque-purified and propagated in large liquid cultures for preparation of recombinant DNA. Plaque-purified phage containing ARV DNA were propagated in liquid culture in *E. coli* DP50supF: phage particles were harvested and banded in CsCl gradients and recombinant phage DNA was prepared by phenol extraction followed by ethanol precipitation (Maniatis, et al, supra). One  $\mu\text{g}$  of purified phage DNA was digested with restriction enzymes, electrophoresed on 1 % agarose gels, and visualized with ethidium bromide under ultraviolet light. The DNA from these gels was transferred to nitrocellulose and annealed with viral cDNA probe.

[0046] One of the 11 phage, designated  $\lambda$  ARV-2(9B), was deposited at the ATCC on 25 January 1985 and given Accession No. 40158.  $\lambda$  ARV-2(9B) contained an insertion of full-length proviral DNA along with flanking cell sequences. Digestion of  $\lambda$  ARV-2(9B) DNA with SacI yielded viral DNA fragments of 3.8 kb and 5.7 kb. EcoRI digestion of  $\lambda$  ARV-2(9B) produced virus containing DNA species at 6.4 kb and 8.0 kb; a double digest of SacI and EcoRI gave viral DNA fragments at 3.8 kb and 5.4 kb. This pattern is consistent with that of a provirus linked to cell DNA.

[0047] In addition to  $\lambda$  ARV-2(9B), phage was obtained that (1) possessed the left half of the viral genome from the EcoRI site in viral DNA extending into flanking cell DNA ( $\lambda$ ARV-2(8A)) and (2) phage that had the right half of the viral genome ( $\lambda$ ARV-2(7D)) from the EcoRI site in viral DNA extending into flanking cell DNA. Bacteriophages  $\lambda$ ARV-2(7D) (right) and  $\lambda$ ARV-2(8A) (left) were deposited at the ATCC on October 26, 1984 and given Accession Nos. 40143 and 40144, respectively.

#### 6. Polymorphism.

[0048] To measure the relatedness of independent ARV isolates, restriction enzyme digests of DNA from HUT-78 cells infected with ARV-3 and ARV-4 were analyzed with the probe made from cloned ARV-2 DNA. The SacI digest of ARV-3 DNA was similar to that of ARV-2 whereas the HindIII digests displayed different patterns. The SacI digest and the PstI digest of ARV-4 DNA differed from the corresponding digests of ARV-2 DNA. The intensity of the annealing signals obtained with ARV-3 and ARV-4 samples was much lower (about 10-fold less) than that for ARV-2 DNA probably as a result of the fact that fewer cells were infected in the ARV-3 and ARV-4 cultures. The viral-specific DNA fragments produced by SacI treatment of ARV-3 and ARV-4 DNA totaled 9.0-9.5 kbp, a value similar to that of ARV-2 and in consonance with the RNA genome sizes.

#### 7. Sequencing of proviral DNA.

[0049] Fragments or subfragments of ARV-2 DNA from X phage 9B were prepared and cloned into M13 according to conventional procedures (Maniatis, et al, supra). Sequencing was performed according to Sanger, et al, Proc Natl Acad Sci USA (1977) 74:5463, using the universal M13 primer or chemically synthesized primers complementary to ARV-2 sequence. The sequence is shown in Figure 2.

## 8. Amino acid sequence analysis of p25 and p16 gag coded proteins.

[0050] ARV-2 was prepared and purified as described in Section 1. The viral proteins were electrophoresed on an acrylamide gel, and the band corresponding to a 24,000 dalton or 16,000 dalton protein was excised from the gel and used for sequencing. Micro-sequence analysis was performed using Applied Biosystems model 470A protein sequencer similar to that described by Hewick, et al, *J Biol Chem* (1981) 256:7990-7997. Phenylthiohydantoin amino acids were identified by HPLC using a Beckman ultrasphere ODS column and a trifluoroacetic acid-acetonitrile buffer system as reported by Hawke, et al, *Anal Biochem* (1982) 120:302-311. Table 1 shows the first 20 amino acids from the amino terminus determined for p25-gag protein and Table 2 shows the first 30 amino acids for p16-gag protein.

TABLE 1

Amino-terminal sequence of p25-gag	
Position	Amino acid
1	Pro
2	Ile
3	Val
4	Gln
5	Asn
6	Leu
7	Gln
8	Gly
9	Gln
10	Met
11	Val
12	(His)
13	Gln
14	Ala
15	Ile
16	(Ser)
17	Pro
18	(Arg, Lys)
19	Thr
20	(Leu)

TABLE 2

Amino-terminal sequence of p16-gag	
Position	Amino acid
1	(Met)
2	Gln
3	Arg
4	Gly
5	Asn
6	Phe
7	Arg
8	Asn
9	Gln
10	Arg
11	Lys
12	Thr
13	Val
14	Lys

TABLE 2 (continued)

Amino-terminal sequence of p16-gag.	
Position	Amino acid
15	--- (Cys)
16	Phe
17	Asn
18	--- (Cys)
19	Gly
20	Lys
21	Glu
22	Gly
23	(His)
24	Ile
25	Ala
26	(Lys)
27	Asn
28	(Gly)
29	(Arg)
30	(Ala, Leu)

[0051] The amino acid sequence of Table 1 is predicted from the ARV-2 DNA sequence of Figure 2. Therefore, these results confirm that the indicated gag open reading frame is in fact being translated and identifies the N-termini of p25 and p16.

#### 9. Expression of p25 gag protein of ARV-2 in bacteria.

##### A. Host-vector system

[0052] The p25 gag protein is synthesized by *E. coli* strain D1210 transformed with plasmid pGAG25-10.

[0053] Plasmid pGAG25-10 is a pBR322 derivative which contains the sequence coding for p25 gag under transcriptional control of a hybrid tac promoter (De Boer et al, PNAS (1983), 80:21-25) derived from sequences of the trp and the lac UV5 promoters. Expression of p25 gag is induced in bacterial transformants with isopropylthiogalactoside (IPTG).

[0054] *E. coli* D1210, a lac-repressor overproducing strain, carries the lacI<sup>q</sup> and lacY<sup>+</sup> alleles on the chromosome but otherwise is identical to *E. coli* HB101 (F<sup>-</sup> lacI<sup>+</sup>, lacO<sup>+</sup>, lacZ<sup>+</sup>, lacY<sup>-</sup>, gal<sup>-</sup>, pro<sup>-</sup>, leu<sup>-</sup>, thi<sup>-</sup>, end<sup>-</sup>, hsm<sup>-</sup>, hsr<sup>-</sup>, recA<sup>-</sup>, rpsL<sup>-</sup>) from which it was derived.

##### B. Construction of pGAG25-10.

[0055] Plasmid pGAG25-10 was constructed by cloning a 699 bp DNA fragment coding for p25 gag into plasmid ptac5, according to the scheme shown in Figure 3. The vector ptac5 is a pBR322 derivative which contains the tac promoter, Shine Delgarno sequences, and a polylinker as a substitution of the original pBR322 sequences comprised between the EcoRI and PvuII restriction sites.

[0056] The 699 bp DNA fragment codes for the complete p25 gag protein (amino acid residues 139 to 369 as numbered in Figure 2), the only difference being that a methionine was added as the first amino acid in pGAG25-10 to allow for translational initiation. This change, as well as other changes in nucleotide sequence as indicated below, was achieved by using chemical synthesis of part of the DNA fragment. The DNA fragment also includes two stop codons at the 3' end of the sequence.

[0057] Figure 4 shows the nucleotide sequence cloned in pGAG25-10 and the amino acid sequence derived from it. DNA sequences that are not underlined in the figure were derived directly from the ARV-2(9B) cDNA. All other sequences were chemically synthesized or derived from vector ptac5. Changes were introduced in this DNA sequence, with respect to the original cDNA, to create or delete restriction sites, to add a methionine prior to the proline (first residue of p25) or to include stop codons after the last codon of p25 gag. However, as previously indicated, all changes in the DNA sequence, except those in the first codon, do not alter the amino acid sequence of p25 gag.



C. Preparation of D1210 (pGAG25-10) strain and characterization of p25 gag protein expressed by transformants.

[0058] *E. coli* D1210 cells are made competent for transformation following a standard protocol (Cohen et al, PNAS (1972) 69:2110). Transformation is performed as indicated in the protocol with 25-50 ng of pGAG25-10. The transformation mix is plated on agar plates made in L-broth containing 100 µg/ml ampicillin. Plates are incubated for 12 hr at 37°C.

[0059] Single ampicillin resistant colonies are transferred into 1 ml L-broth containing 100 µg/ml ampicillin and grown at 37°C. Expression of p25 gag protein is induced by adding 10 µl of 100 mM IPTG (Sigma) to a final concentration of 1 mM followed by incubation at 37°C for 2 hr.

[0060] Cells from 1 ml of induced cultures are pelleted and resuspended in 100 µl Laemmli sample buffer. After 3 cycles of boiling and freezing, portions of resultant lysates are analyzed on standard denaturing acrylamide gels. Proteins are visualized by staining with Coomassie blue.

[0061] The extent of expression is initially determined by appearance of new protein bands for induced candidate samples compared with control. Proteins of molecular weights expected for the genes expressed comprised 2%-5% of total cell protein in the highest expressing recombinants as determined by visual inspection with reference to a standard protein of known amount.

[0062] Authenticity of the expressed proteins is determined by standard Western transfer of proteins to nitrocellulose and analysis with appropriate human or rabbit immune sera or mouse monoclonal antibodies (see E.4.a. below) or by ELISA assays of soluble *E. coli* proteins using human immune sera from AIDS patients (see E.4.b. below).

D. Fermentation process.

D.1. Preparation of transformant master seed stock.

[0063] Transformant cells from a culture expressing high levels (3%) of p25 gag are streaked onto an L-broth plate containing 100 µg/ml ampicillin and the plate is incubated overnight at 37°C. A single colony is inoculated into 10 ml of L-broth, 100 µg/ml ampicillin and grown overnight at 37°C. An aliquot is used to verify plasmid structure by restriction mapping with *Sall* and *Pst*I. A second aliquot is used to induce expression of p25 gag and the rest of the culture is made 15% glycerol by adding 1/4 volume of 75% sterile glycerol. Glycerol cell stocks are aliquoted in 1 ml and quickly frozen in liquid nitrogen or dry-ice ethanol bath. These master seed stocks are stored at -70 °C.

D.2. Master plate/single colonies and overnight cultures.

[0064] The master seed stock is scraped with a sterile applicator which is used to streak an L-broth plate containing 100 µg/ml ampicillin. Single colonies from this plate are used to inoculate 20-50 ml of L-broth/amp, which is incubated at 37°C overnight.

D.3. Fermentor inoculum.

[0065] An aliquot of the overnight culture is used to inoculate larger volumes (1-6 liters) of L-broth/amp. Cells are incubated at 37°C overnight and reach an O.D.<sub>650</sub> of approximately 5 prior to use as inoculum for the fermenter run.

D.4. Fermentation and harvest.

[0066] Fermenters (capacity: 16 liters) containing 10 l of L-broth and 1 ml of antifoam are inoculated with 100-500 ml from the inoculum culture. Cells are grown at 37°C to an O.D. of about 1. Expression of p25 gag is induced by addition of 100 ml of an IPTG solution (100 mM) to yield a 1 mM final concentration in the fermenter. Cells are grown for 3 additional hours and subsequently harvested using continuous flow centrifugation. At this step cells may be frozen and kept at -20°C until purification of p25 gag proceeds. Alternatively, 250 l fermenters are inoculated with 1-5 l from the inoculum culture. Growth, induction, and harvest are as indicated before.

E. Purification and characterization of p25 gag.

E.1. Cell breakage.

[0067] Frozen *E. coli* cells are thawed and suspended in 2.5 volumes of lysis buffer (0.1M sodium phosphate (NaPi), pH 7.5, 1 mM EDTA, 0.1 M NaCl). Cells are broken in a non-continuous system using a 300 ml glass unit of a Dyno Mill at 3000 rpm and 140 ml of acid-washed glass beads for 15 min. The jacketed chamber is kept cool by a -20°C

ethylene glycol solution. Broken cells are centrifuged at 27.000 x g for 25 minutes to remove debris and glass beads. The supernatant is recovered and kept at 4°C.

## E.2. Selective protein precipitation.

[0068] The cell extract is made 30%  $(\text{NH}_4)_2\text{SO}_4$  by slowly adding the ammonium sulfate at 4°C. The extract is stirred for 10 min after the final concentration is achieved, followed by centrifugation at 27.000 x g for 20 min. The pellet is resuspended in 1 M NaCl, 1 mM EDTA, 1% Triton® X-100, and 5% SDS, and then boiled for 5 min.

## E.3. Gel filtration.

[0069] The fraction obtained by selective precipitation is submitted to gel filtration using a G50 Sephadex column equilibrated in 0.03 M NaPi, pH 6.8. Chromatography is developed in the same solution. Fractions are collected and absorbance at 280 nm is determined. Protein-containing fractions are pooled and characterized by protein gel electrophoresis, Western analysis, and ELISA.

## E.4. Characterization of recombinant p25 gag.

### [0070]

a. Protein gel electrophoresis. SDS-polyacrylamide gel analysis (10%-20% gradient gels) of proteins from pGAG25-containing cells and control cells indicated that varying levels of a protein of a molecular weight of about 25,000 were specifically induced in cells containing p25 gag expression plasmids after derepression of the tacI promoter with IPTG. Identity of the p25 gag gene product was confirmed by both an enzyme-linked immunosorbent assay (ELISA, see E.4.c.) and Western immunoblot analysis (see E.4.b.) using both AIDS patient serum and a monoclonal antibody to viral p25 gag.

b. Western analysis. Samples were electrophoresed under denaturing conditions on a 10%-20% polyacrylamide gradient gel. Samples were electroblotted onto nitrocellulose. The nitrocellulose paper was washed with a 1:250 dilution of AIDS patient reference serum (EW5111, obtained from P. Feorino, Centers for Disease control, Atlanta, Georgia) and then with a 1:500 dilution of HRP-conjugated goat antiserum to human immunoglobulin (Cappel, No. 3201-0081). Alternatively, the nitrocellulose was washed with undiluted culture supernatant from 76C, a murine monoclonal antibody to ARV-2 p25 gag, and then with a 1:500 dilution of HRP-conjugated goat antiserum to mouse immunoglobulin (TAGO, No. 6450). The substrate for immunoblots was HRP color development reagent containing 4-chloro-1-naphthol.

The p25 gag protein reacted with both AIDS patient reference serum and with the monoclonal antibody, while it shows no reactivity with the non-immune serum.

c. ELISA. p25 gag was purified from bacterial extracts as previously described. The reactivity of sera with the purified protein was assayed by coating wells of microtiter plates with 0.25 µg/ml, adding dilutions of test sera (positive reference serum EW5111 of human negative serum), followed by a 1:1000 dilution of HRP-conjugated goat antiserum to human immunoglobulin. p25 gag protein reacted with the positive serum with a midpoint of titration curve of approximately 1:800. There was no reactivity with serum from a normal individual.

## 10. Comparison of recombinant p25 gag protein and natural p25 gag protein in ELISA.

[0071] The reactivity of purified recombinant p25 gag to various sera was compared to that of natural p25 gag protein purified by preparative polyacrylamide gel electrophoresis in an ELISA assay. For control, assays were also made using disrupted gradient purified virus (5 µg/ml).

[0072] PVC microtiter plates were incubated for 2 hr at 37°C with 10 µg/ml (50 µl/well in 0.1 M sodium borate, pH 9.0) of the Ig fraction of ascites from murine anti-p25 gag monoclonal antibody 76C. The plates were washed with PBS and the wells were filled with 10% normal goat serum in PBS. Following a 30 min incubation at room temperature, the plates were washed with normal saline containing 0.05% Triton® X-100 (ST) and dilutions of the test ARV protein (50 µl/well in ST with 10% goat serum (STGS)) were added to the wells. The plates were incubated for 2 hr at 37°C, washed with ST, and then incubated for 1 hr at 37°C with 50 µl/well of rabbit antiserum raised against disrupted ARV (1:1000 dilution in STGS). The wells were washed, incubated for 1 hr with 50 µl of a 1:1500 dilution in STGS of HRP-conjugated goat antiserum to rabbit immunoglobulin, washed, and then the wells received 50 µl/well of substrate solution (150 µg/ml 2,2'-azino-di-[3-ethybenzthiazolene sulfonic acid], 0.001%  $\text{H}_2\text{O}_2$ , 0.1 M citrate pH 4). The reaction was stopped after incubation for 30 min at 37°C by the addition of 50 µl/well of 10% SDS. The absorbance was read on a Flow Titertech ELISA reader at 414 nm. Samples were assayed in duplicate beginning at a dilution of 1:10 and by serial

2-fold dilutions thereafter.

[0073] The table below summarizes the results of assays on 8 AIDS sera that scored positive in the assay with disrupted virus and 6 normal sera that were negative in the disrupted virus assay.

SERUM NUMBER	ELISA ASSAY TITER <sup>a</sup>		
	Disrupted Virus	Recomb. p25 gag	Viral p25 gag
Group I: Sera Scoring As Positive in Virus ELISA <sup>b</sup>			
1	51,200	3,125	3,125
5	12,800	25	25
6	12,800	625	625
7	12,800	3,125	3,125
8	25,600	15,625	15,625
9	12,800	625	625
13	800	125	125
18	3,200	625	625
Group II: Sera Scoring Negative in Virus ELISA <sup>b</sup>			
15	- <sup>c</sup>	-	-
16	-	-	-
19	-	-	-
21	-	-	-
26	-	-	-
33	-	-	-

a. Reported as the reciprocal of the serum dilution that gave a signal equivalent to 50% of the maximum.

b. Results were confirmed by immunofluorescence and immunoblotting as described previously.

c. No detectable signal at a 1:25 serum dilution.

[0074] These results show that p25 gag purified from bacteria behaves identically to similarly purified p25 gag from AIDS virus in an ELISA of the eight AIDS patient sera. The results of the ELISA show that there is a wide variation in the levels of anti-p25 gag antibodies and suggests that antibodies to some virus-encoded proteins may not be detected using conventional virus-based assay systems.

#### 11. Expression of p41 gag protein of ARV-2 in bacteria.

[0075] A fusion protein of the p25 gag and p16 gag proteins of ARV-2, designated p41 gag, was synthesized in *E. coli* strain D1210 transformed with plasmid pGAG41-10. pGAG41-10 was constructed from plasmid pGAG25-10 as shown in Figure 3 by inserting an *SphI*-*HpaI* fragment from the ARV-2 genome containing the sequences from the C-terminal p16 gag portion of the p53 gag precursor polypeptide and part of the p25 gag protein between the *SphI* and *BamHI* sites of pGAG25-10. The coding strand of the DNA sequence cloned in pGAG41-10 is shown in Figure 5. Transformation and induction of expression were effected by the procedures described above. The cells were treated and the p41 gag protein was visualized on Coomassie-stained gel as described above. The approximate molecular weight of the observed protein was 41,000 daltons. The protein reacted with AIDS sera and monoclonal antibody to p25 gag in Western and ELISA analyses carried out as above.

#### 12. Expression of p16 gag protein of ARV-2 in bacteria.

[0076] The sequence shown in Figure 6 and coding for the p16 gag protein was chemically synthesized using yeast-preferred codons. The blunt-end *Sall* fragment (381 bp) was cloned into *PvuII*-*Sall* digested and gel-isolated pTac5 (see 9 and 11 above). The resulting plasmid was used to transform D1210 cells, as in 9 above. Expression was induced with IPTG, and proteins were analyzed by polyacrylamide gel electrophoresis and Western analysis. A band of about 16,000 daltons was induced by IPTG in the transformed cells. This protein showed reactivity in Western blots with immune sera from AIDS patients. No reactivity was observed with sera from normal individuals.

[0077] A recombinant gag protein was also expressed in Cos (mammalian) cells.

13. Production of ARV-2 env protein by yeast.A. Host-vector system.

5 [0078] A partial env protein is synthesized by *S. cerevisiae* 2150-2-3 transformed with plasmid pDPC303. Plasmid pDPC303 is a yeast expression vector which contains the sequence coding for 2/3 of the env protein as well as pBR322 sequences including the amp<sup>R</sup> gene and 2-micron sequences including the yeast leu 2-04 gene. Expression of env is under regulation of the yeast pyruvate kinase promoter and terminator sequences. Yeast strain *S. cerevisiae* 2150-2-3 has the following genotype: Mat a, ade 1, leu 2-112, cir<sup>o</sup>. This strain was obtained from Dr. Leland Hartwell, University  
10 of Washington.

B. Construction of pDPC303, a yeast expression vector for env protein.

15 [0079] Plasmid pDPC303 contains an "expression cassette" (described below) for env cloned into the BamHI site of vector pCI/I. Vector pCI/I contains pBR322 and 2 micron sequences including the amp<sup>R</sup> and yeast leu 2-04 markers. It was derived from pJDB219d (Beggs, Nature (1978), 275: 104) by replacing the pMB9 region with pBR322 sequences. [0080] The "expression cassette" for env consists of the following sequences fused together in this order (5' to 3'): yeast pyruvate kinase (PYK) promoter, env cDNA, and PYK terminator. The PYK promoter and terminator regions were derived from PYK cDNA isolated as described in Burke, et al, *J Biol Chem* (1983) 258:2193-2201.  
20 [0081] The env fragment cloned into the expression cassette was derived from ARV-2 cDNA and comprises a 1395 bp cDNA fragment which codes for env amino acid residues coded by nt 5857 to nt 7251 (Figure 2). In addition, there are 5 extra codons fused in reading frame in the 5' end, the first codon corresponding to a methionine, and 4 extra codons fused in reading frame at the 3' end followed by a stop codon. The extra codons were incorporated to facilitate cloning procedures exclusively.  
25 [0082] Figure 7 shows the coding strand of the nucleotide sequence cloned in pDPC303 and the amino acid sequence derived from it. DNA sequences that are not underlined in the figure were derived directly from the ARV-2 (9B) cDNA described above. All other sequences were either chemically synthesized or derived from the PYK vector.

C. Preparation of 2150 (pDPC303) strain

30 [0083] Yeast cells *S. cerevisiae* 2150-2-3 (Mat a, ade 1, leu 2-04, cir<sup>o</sup>) were transformed as described by Hinnen et al (PNAS (1978) 75:1929-1933) and plated onto leu- selective plates. Single colonies were inoculated into leu- selective media and grown to saturation. Cells were harvested and the env protein was purified and characterized as described below.  
35

D. Purification and characterization of env protein.D.1. Cell breakage.

40 [0084] Frozen *S. cerevisiae* 2150-2-3 (pDPC303) are thawed and suspended in 1 volume of lysis buffer (1 µg/ml pepstatin, 0.001 M PMSF, 0.001 M EDTA, 0.15 M NaCl, 0.05 M Tris-HCl pH 8.0), and 1 volume of acid-washed glass beads are added. Cells are broken in a non-continuous system using a 300 ml glass unit of Dyno Mill at 3000 rpm for 10 min. The jacket is kept cool by a -20°C ethylene glycol solution. Glass beads are decanted by letting the mixture set for 3 minutes on ice. The cell extract is recovered and centrifuged at 18,000 rpm (39,200 x g) for 35 min. The  
45 supernatant is discarded and the precipitate (pellet 1) is further treated as indicated below.

D.2. SDS extraction of insoluble material.

50 [0085] Pellet 1 is resuspended in 4 volumes of Tris-HCl buffer (0.01 M Tris-HCl, pH 8.0, 0.01 M NaCl, 0.001 M PMSF, 1 µg/ml pepstatin, 0.001 M EDTA, 0.1% SDS) and extracted for 2 hr at 4°C with agitation. The solution is centrifuged at 6,300 x g for 15 min. The insoluble fraction (pellet 2) is resuspended in 4 volumes (360 ml) of PBS (per liter: 0.2 g KCl, 0.2 g KH<sub>2</sub>PO<sub>4</sub>, 8.0 g NaCl, 2.9 g Na<sub>2</sub>HPO<sub>4</sub>·12H<sub>2</sub>O), 0.1% SDS, 0.001 M EDTA, 0.001 M PMSF, 1 µg/ml pepstatin, and centrifuged at 6,300 x g for 15 min. The pellet (pellet 3) is suspended in 4 volumes of PBS, 0.2% SDS, 0.001 M EDTA, 0.001 M PMSF, 1 µg/ml pepstatin and is extracted for 12 hr at 4°C with agitation on a tube rocker. The solution  
55 is centrifuged at 6,300 x g for 15 min. The soluble fraction is recovered for further purification as indicated below. (The pellet can be reextracted by resuspending it in 4 volumes of 2.3% SDS, 5% β-mercaptoethanol, and boiling for 5 min. After boiling, the solution is centrifuged at 6,300 x g for 15 min. The soluble fraction is recovered for further purification.)

D.3. Selective precipitation and gel filtration.

[0086] The soluble fraction is concentrated by precipitation with 30% ammonium sulfate at 4°C. The pellet (pellet 4) is resuspended in 2.3% SDS, 5% β-mercaptoethanol, and chromatographed on an ACA 34 (LKB Products) gel filtration column. The column is equilibrated with PBS, 0.1% SDS, at room temperature. Chromatography is developed in the same solution with a flow rate of 0.3 ml/min. Five ml fractions are collected, pooled and characterized by protein gel electrophoresis, Western analysis, and ELISA. If needed, pooled fractions are concentrated by vacuum dialysis on Spectrapor #2 (MW cutoff 12-14K).

D.4. Characterization of recombinant env.

[0087] SDS polyacrylamide gel analysis (12% acrylamide gels) showed that a new 55,000 dalton protein was being synthesized in yeast cells transformed with the env-containing vector. The 55,000 dalton protein is absent from cells transformed with control plasmid (vector without env insert). The identity of env was confirmed by both ELISA (see 9.E.4.c) and Western analysis using AIDS patient serum. In both assays the 55,000 dalton protein showed immunoreactivity. No reactivity was obtained with serum from a normal individual.

[0088] Recombinant env was also expressed in mammalian (Cos) cells.

14. ELISA for antibodies to HIV-I using recombinant ARV-2 polypeptides

[0089] Stock solutions of purified p25 gag protein (1.25 mg/ml in 20 mM sodium phosphate, 0.1% SDS, pH 7.2), purified env protein (2 mg/ml in 20 mM sodium phosphate, 0.1% SDS, pH 7.2), and purified SOD-p31 fusion protein (2 mg/ml in 20 mM sodium phosphate, 0.1% SDS, pH 7.2) were prepared.

[0090] For coating microtiter plates (Dynatech Immulon I), 1 part each of the stock solutions of p25 gag, env, and SOD-p31 were added to 997 parts of borate coating buffer (0.05 M borate, pH 9.0). One hundred microliters of the coating solution was added to each well, and the plates were covered and incubated 2 hr at 37°C or 12 hr at 4°C. The coating solution was then aspirated from the wells and the plates washed 6 x with wash solution (0.137 M 0.8% NaCl, 0.05% Triton® X-100).

[0091] Serum samples were diluted 1:100 in dilution solution (0.1% casein, 1 mM EDTA, 1% Triton® X-100, 0.5 M NaCl, 0.01% thimerosal, pH 7.5) with yeast protein (strain AB103.1) extract (1:40 dilution, approximately 2 mg protein per ml in PBS containing 1% Triton X-100, 2 mM PMSF, 0.01% thimerosal) and *E. coli* protein extract (1:40 dilution, approximately 1 mg protein per ml in PBS containing 1% Triton® X-100, 2 mM PMSF, 0.01% thimerosal) added to the dilution solution. Extraction procedures were similar to those described in 13 and 14 above but using non-recombinant strains. One hundred microliters of diluted serum was added to each well and incubated 30 min at 37°C. The plates were then washed 6 x with wash solution.

[0092] Goat anti-human Ig labeled with horseradish peroxidase (Cappel) diluted 1:8000 in dilution solution without added yeast and *E. coli* extracts were added at 100 µl/well to the plates and incubated 30 min at 37°C. The plates were then washed 6 x with wash solution. Substrate solution (10 ml citrate buffer, 10.5 g citric acid/liter dH<sub>2</sub>O, pH to 4.0 with 6 M NaOH), 0.1 ml ABTS (15 mg/ml 2,2'-azino-di-(3-ethyl-benz-thiazolene sulfonic acid) in dH<sub>2</sub>O) and 3.33 µl H<sub>2</sub>O<sub>2</sub>) at 100 µl/well was then added to the plates and the plates wrapped in foil and incubated at 37°C for 30 min. The reaction was then stopped by adding 50 µl/well of 10% SDS. Readings were made with a Dynatech ELISA reader set for dual wavelength reading: absorbance wavelength of 1 (410 nm) and reference wavelength of 4.

Results

[0093] The following sera were tested:

A. 89 consecutive blood donors from the Kansas City Blood Bank ("normal blood donors"): log nos. 1001-1081, 1085-1092.

B. 52 sera from patients with lymphadenopathy syndrome (LAD) or AIDS or sexual partners of persons with LAD or AIDS (referred to as "contacts")--all obtained from UCSF AIDS Serum Bank panel: log nos. 4601-4652.

[0094] The positive/negative cut-off used was 5 x (average background signal - signal with diluent alone) and was determined to be 0.195. Thus, sera with signals below 0.195 were rated (-); those above were rated (+). Each sample was also evaluated by the commercially available ABBOTT HTLV III EIA kit (Abbott Labs) and by Western analysis.

[0095] Tests on the normal blood donor samples indicated all except one were negative in the invention ELISA. This normal serum scored negative in the ABBOTT HTLV III EIA test, but was actually positive, as confirmed by Western analysis.

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[0096] The results of the tests on the 52 sera from LAD and AIDS patients and contacts are tabulated below:

	Serum No.	Diagnosis	ABBOTT EIA	Invention ELISA		Western
5	4601	Contacts	+	1.89	+	+
	02	Contacts	-	0.04	-	-
	03	Contacts	+	1.44	+	+
	04	Contacts	+	1.92	+	+
	05	Contacts	-	0.04	-	-
10	06	Contacts	+	>2	+	+
	07	Contacts	+	1.37	+	+
	08	Contacts	+	1.60	+	+
	09	Contacts	+	>2	+	+
15	10	Contacts	+	>2	+	+
	11	Contacts	+	1.94	+	+
	12	Contacts	+	>2	+	+
	13	Contacts	+	>2	+	+
	14	Contacts	+	>2	+	+
20	15	Contacts	+	1.97	+	+
	16	AIDS	+	0.61	+	+
	17	AIDS	+	>2	+	+
	18	AIDS	+	>2	+	+
25	19	AIDS	+	1.58	+	+
	20	AIDS	+	1.58	+	+
	21	AIDS	+	0.76	+	+
	22	AIDS	+	1.74	+	+
	23	LAD	+	1.26	+	+
30	24	LAD	+	>2	+	+
	25	AIDS	+	1.04	+	+
	26	AIDS	+	1.24	+	+
	27	AIDS	+	1.40	+	+
35	28	AIDS	-	0.07	-	-
	29	LAD	+	1.93	+	+
	30	Contacts	+	1.96	+	+
	31	AIDS	+	1.76	+	+
	32	AIDS	+	0.90	+	+
40	33	AIDS	+	1.69	+	+
	34	LAD	+	1.09	+	+
	35	AIDS	+	1.54	+	+
	36	AIDS	+	1.22	+	+
45	37	AIDS	+	1.96	+	+
	38	AIDS	-	>2	+	+
	39	LAD	+	1.85	+	+
	40	LAD	+	>2	+	+
	41	LAD	+	0.84	+	+
50	42	LAD	+	1.59	+	+
	43	LAD	+	1.71	+	+
	44	AIDS	+	1.40	+	+
	45	LAD	+	>2	+	+
55	46	AIDS	+	1.38	+	+
	47	AIDS	+	1.29	+	+
	48	LAD	+	1.93	+	+
	49	LAD	+/-	0.48	+	+

(continued)

Serum No.	Diagnosis	ABBOTT EIA	Invention ELISA		Western
50	LAD	-	0.04	-	-
51	LAD	-	0.07	-	-
52	LAD	+	1.92	+	+

[0097] The above results show that the invention ELISA using recombinant ARV proteins is at least as good as the ABBOTT HTLV III EIA test or Western analysis.

[0098] In the invention ELISA reported in this example the yeast and bacterial extracts were added to the serum to bind serum antibodies to yeast and bacteria to prevent such antibodies from binding to the recombinant ARV-2 proteins. Both yeast and bacterial extracts were required since the recombinant polypeptides included polypeptides expressed in yeast and polypeptides expressed in bacteria. If all the polypeptides were expressed in the same type of organism, only one extract would be needed. For instance, if a p25 gag polypeptide expressed in yeast was substituted for the bacterially produced p25 gag polypeptide of the example, only yeast extract would be added to the serum samples.

#### 15. Dot-blot assay for antibodies to HIV-I using recombinant ARV-2 polypeptides.

[0099] Nitrocellular strips (0.5 x 5 cm) are spotted with 50 ng polypeptide in PBS (spotting volume 2 µl). After spotting the strips are dried at room temperature for 1 hr or more. The strips are then post-coated in a 5% solution of Carnation non-fat dry milk in PBS, 0.01% Thimerosal, for 15-60 min at room temperature. Each test solution sample is diluted 1:50 in 0.5 ml of the post-coating solution in a test tube. A post-coated strip is then placed in the tube and incubated in the sample with rocking at 37°C for 1 hr. The strip is then removed from the tube and washed with post-coating solution. The strip is then incubated for 15 min at room temperature in goat anti-human Ig reagent labeled with horse radish peroxidase diluted 1:500 in post-coating solution. After incubation in the labeled antibody, the strip is washed serially with PBS, 1% Triton, and distilled water. The strips are developed by incubating them in substrate solution (see 23 above) for 15 min at room temperature.

[0100] Positive samples will cause a visually perceptible color change at the spotting site. Normal (negative) sera sample yield no color change or give a faint signal that is discernible from a positive signal. Competition assays may be run on sera giving faint signals to verify that they are negative. In the competition assay, polypeptide (10-25 µg/ml) is added to the test sample and incubated from 1 hr at 37°C before the strip is incubated in the sample. With authentic positive sera the signal is completely blocked by the added polypeptide, whereas with normal (negative) sera there is no change in signal.

[0101] Samples of organisms that express the above-described ARV-2 p25 gag and ARV-2 env polypeptides were deposited at the American Type Culture Collection (ATCC), 12301 Parklawn Drive, Rockville, Maryland under the provisions of the Budapest Treaty. The accession numbers and dates of these deposits are listed below.

Expression Product	ATCC Accession No.	Deposit Date
ARV-2 p25 gag	53246	27 August 1985
ARV-2 env	20769	27 August 1985

#### Claims

1. A recombinant DNA construct useful for the expression of a recombinant polypeptide in a cell containing the construct, the construct comprising control sequences which regulate transcription and translation of the recombinant polypeptide in the cell and a coding sequence regulated by the control sequences, wherein the coding sequence comprises a DNA sequence of at least about 21 bp in reading frame **characterised in that** the DNA sequence encodes an antigenic HIV-I gag or env amino acid sequence of Figure 2 which sequence is immunologically non-cross-reactive with HTLV-I and HTLV-II and is reactive with HIV-I.
2. A recombinant DNA construct according to claim 1, which is useful for expression in a eukaryotic cell.
3. A recombinant DNA construct according to claim 1, which is useful for expression in a yeast cell.
4. A recombinant DNA construct according to claim 1, which is useful for expression in a bacterial cell.

5. A recombinant DNA construct according to any one of claims 1 to 4, **characterised in that** the DNA sequence encodes an amino acid sequence from an env polypeptide of HIV-I.
6. A recombinant DNA construct according to claim 5, wherein the DNA sequence encodes a complete env polypeptide.
7. A recombinant DNA construct according to any one of claims 1 to 4, **characterised in that** the DNA sequence encodes an amino acid sequence from a gag polypeptide of HIV-I.
8. A recombinant DNA construct according to claim 7, wherein the DNA sequence encodes a complete gag polypeptide.
9. A cell comprising a recombinant DNA construct according to any one of claims 1 to 8, wherein the cell expresses the antigenic HIV-I amino acid sequence and is free from other cells which do not express the antigenic HIV-I amino acid sequence.
10. A cell according to claim 9, wherein the recombinant DNA construct comprises a replication system recognised by the cell.
11. A cell according to claim 10, wherein the cell is eukaryotic.
12. A cell according to any one of claims 9 to 11, which is a yeast.
13. A method of producing a recombinant polypeptide comprising an antigenic HIV-I amino acid sequence wherein a population of cells according to claim 9 is cultured under conditions whereby the recombinant polypeptide is expressed.
14. A method according to claim 13, wherein the cells are eukaryotic.
15. A method according to claim 13, wherein the cells are yeast or bacteria.
16. An immunoassay for detecting antibodies to HIV-I in a sample suspected of containing the antibodies, **characterised in that** at least one recombinant polypeptide is used to bind the antibodies and the recombinant polypeptide comprises an antigenic env or gag HIV-I amino acid sequence contained in the sequence shown in Figure 2, which polypeptide is immunologically non-cross-reactive with HTLV-I and HTLV-II.
17. An immunoassay according to claim 16, wherein at least one env amino acid sequence and one gag amino acid sequence are used to bind the antibodies.
18. A diagnostic reagent or immunogen capable of binding an anti-HIV-I antibody in human serum **characterised in that** said reagent or immunogen consists of an antigen comprising an immunogenic fragment of at least seven amino acids of an HIV-I env or gag polypeptide, which fragment is immunologically non-cross-reactive with HTLV-I and HTLV-II and which has a sequence contained in the sequence shown in Figure 2.
19. A recombinant polypeptide **characterised in that** it is produced by a cell transformed by a recombinant DNA construct according to claim 5.
20. A recombinant polypeptide **characterised in that** it is produced by a cell transformed by a recombinant DNA construct according to claim 6.
21. A recombinant polypeptide **characterised in that** it is produced by a cell transformed by a recombinant DNA construct according to claim 7.
22. A recombinant polypeptide according to claim 21, wherein the gag amino acid sequence comprises p16 gag.
23. A recombinant polypeptide according to claim 21, wherein the gag amino acid sequence comprises p25 gag.
24. A recombinant polypeptide according to claim 21, wherein the gag amino acid sequence comprises a fusion protein



of p16 gag and p25 gag amino acid sequences.

25. An article of manufacture for use in an immunoassay for HIV-I antibodies **characterised in that** it comprises a solid support having bound thereto a recombinant polypeptide according to claim 19.
26. An article of manufacture for use in an immunoassay for HIV-I antibodies **characterised in that** it comprises a solid support having bound thereto a recombinant polypeptide according to claim 21.
27. A DNA sequence encoding an HIV-I polypeptide derived from a phage selected from ARV-2 (7D) (ATCC No. 40143) and ARV-2 (8A) (ATCC No. 40144).
28. A recombinant DNA construct capable of expressing an antigenic recombinant HIV-I polypeptide derived from organism ATCC No. 53246.
29. An isolated polynucleotide comprising a fragment of at least 21 bp from the gag or env region of the ARV-2 sequence of Figure 2, wherein said polynucleotide is not greater than 180 bp.

#### Patentansprüche

1. Rekombinantes DNA-Konstrukt zur Expression eines rekombinanten Polypeptids in einer das Konstrukt enthaltenden Zelle, wobei das Konstrukt Kontrollsequenzen umfasst, die die Transkription und die Translation des rekombinanten Polypeptids in der Zelle regulieren und eine von den Kontrollsequenzen regulierte codierende Sequenz, wobei die codierende Sequenz eine DNA-Sequenz von mindestens etwa 21 bp im Leserahmen umfasst, **dadurch gekennzeichnet, dass** die DNA-Sequenz eine antigene HIV-Igag- oder -env-Aminosäuresequenz von Figur 2 codiert, wobei die Sequenz immunologisch nicht kreuzreaktiv mit HTLV-I und HTLV-II und mit HIV-I reaktiv ist.
2. Rekombinantes DNA-Konstrukt nach Anspruch 1 zur Expression in einer eukaryontischen Zelle.
3. Rekombinantes DNA-Konstrukt nach Anspruch 1 zur Expression in einer Hefezelle.
4. Rekombinantes DNA-Konstrukt nach Anspruch 1 zur Expression in einer bakteriellen Zelle.
5. Rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die DNA-Sequenz eine Aminosäuresequenz eines env-Polypeptids von HIV-I codiert.
6. Rekombinantes DNA-Konstrukt nach Anspruch 5, wobei die DNA-Sequenz ein komplettes env-Polypeptid codiert.
7. Rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die DNA-Sequenz eine Aminosäuresequenz eines gag-Polypeptids von HIV-I codiert.
8. Rekombinantes DNA-Konstrukt nach Anspruch 7, wobei die DNA-Sequenz ein komplettes gag-Polypeptid codiert.
9. Zelle, die ein rekombinantes DNA-Konstrukt nach einem der Ansprüche 1 bis 8 umfasst, wobei die Zelle die antigene HIV-I-Aminosäuresequenz exprimiert und frei von anderen Zellen ist, die die antigene HIV-I-Aminosäuresequenz nicht exprimieren.
10. Zelle nach Anspruch 9, wobei das rekombinante DNA-Konstrukt ein von der Zelle erkanntes Replikationssystem umfasst.
11. Zelle nach Anspruch 10, wobei die Zelle eukaryontisch ist.
12. Zelle nach einem der Ansprüche 9 bis 11, wobei die Zelle eine Hefezelle ist.
13. Verfahren zur Herstellung eines rekombinanten Polypeptids, das eine antigene HIV-I-Aminosäuresequenz umfasst, wobei eine Population von Zellen nach Anspruch 9 unter Bedingungen gezüchtet wird, unter denen das rekombinante Polypeptid exprimiert wird.

14. Verfahren nach Anspruch 13, wobei die Zellen eukaryontisch sind.
15. Verfahren nach Anspruch 13, wobei die Zellen Hefe- oder Bakterienzellen sind.
- 5 16. Immunassay zum Nachweis von Antikörpern gegen HIV-I in einer Probe, von der angenommen wird, dass sie die Antikörper enthält, **dadurch gekennzeichnet, dass** mindestens ein rekombinantes Polypeptid zur Bindung der Antikörper verwendet wird und das rekombinante Polypeptid eine antigene env- oder gag-HIV-I-Aminosäuresequenz umfasst, die in der in Figur 2 gezeigten Sequenz enthalten ist, wobei das Polypeptid mit HTLV-I und HTLV-II immunologisch nicht kreuzreaktiv ist.
- 10 17. Immunassay nach Anspruch 16, wobei mindestens eine env-Aminosäuresequenz und eine gag-Aminosäuresequenz zur Bindung der Antikörper verwendet werden.
- 15 18. Diagnostisches Reagenz oder Immunogen, fähig zur Bindung eines anti-HIV-I-Antikörpers in menschlichem Serum, **dadurch gekennzeichnet, dass** das Reagenz oder Immunogen aus einem Antigen besteht, das ein immunogenes Fragment von mindestens sieben Aminosäuren eines HIV-I-env- oder -gag-Polypeptids umfasst, wobei das Fragment mit HTLV-I und HTLV-II immunologisch nicht kreuzreaktiv ist und eine in der in Figur 2 gezeigten Sequenz enthaltene Sequenz besitzt.
- 20 19. Rekombinantes Polypeptid, **dadurch gekennzeichnet, dass** es von einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 5 transformiert ist.
- 25 20. Rekombinantes Polypeptid, **dadurch gekennzeichnet, dass** es von einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 6 transformiert ist.
21. Rekombinantes Polypeptid, **dadurch gekennzeichnet, dass** es von einer Zelle hergestellt wird, die mit einem rekombinanten DNA-Konstrukt nach Anspruch 7 transformiert ist.
- 30 22. Rekombinantes Polypeptid nach Anspruch 21, wobei die gag-Aminosäuresequenz p16-gag umfasst.
23. Rekombinantes Polypeptid nach Anspruch 21, wobei die gag-Aminosäuresequenz p25-gag umfasst.
24. Rekombinantes Polypeptid nach Anspruch 21, wobei die gag-Aminosäuresequenz ein Fusionsprotein aus p16-gag- und p25-gag-Aminosäuresequenzen umfasst.
- 35 25. Erzeugnis zur Verwendung in einem Immunassay für HIV-I-Antikörper, **dadurch gekennzeichnet, dass** es einen festen Träger umfasst, an den ein rekombinantes Polypeptid nach Anspruch 19 gebunden ist.
- 40 26. Erzeugnis zur Verwendung in einem Immunassay für HIV-I-Antikörper, **dadurch gekennzeichnet, dass** es einen festen Träger umfasst, an den ein rekombinantes Polypeptid nach Anspruch 21 gebunden ist.
27. DNA-Sequenz, die ein HIV-I-Polypeptid codiert, das von einem Phagen stammt, der ausgewählt ist aus ARV-2 (7D) (ATCC Nr. 40143) und ARV-2 (8A) (ATCC Nr. 40144).
- 45 28. Rekombinantes DNA-Konstrukt, fähig zur Expression eines antigenen rekombinanten HIV-I-Polypeptids, das aus dem Organismus mit der ATCC Nr. 53246 stammt.
29. Isoliertes Polynucleotid, das ein Fragment mit mindestens 21 bp der gag- oder env-Region der ARV-2-Sequenz aus Figur 2 umfasst, wobei das Polypeptid nicht größer als 180 bp ist.
- 50

#### Revendications

- 55 1. Produit d'assemblage d'ADN recombinant, utile pour l'expression d'un polypeptide recombinant dans une cellule contenant le produit d'assemblage, le produit d'assemblage comprenant des séquences régulatrices qui règlent la transcription et la traduction du polypeptide recombinant dans la cellule et une séquence codante régulée par les séquences régulatrices, dans lequel la séquence codante comprend une séquence d'ADN d'au moins environ 21 pb dans le cadre de lecture, **caractérisé en ce que** la séquence d'ADN code pour une séquence antigénique

d'acides aminés gag ou env du VIH-I de la figure 2, ladite séquence ne présentant pas immunologiquement de réaction croisée avec le HTLV-I ni le HTLV-II et étant réactive avec le VIH-I.

- 5 2. Produit d'assemblage d'ADN recombinant selon la revendication 1, utile pour l'expression dans une cellule eucaryote.
3. Produit d'assemblage d'ADN recombinant selon la revendication 1, utile pour l'expression dans une cellule de levure.
- 10 4. Produit d'assemblage d'ADN recombinant selon la revendication 1, utile pour l'expression dans une cellule bactérienne.
- 15 5. Produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** la séquence d'ADN code pour une séquence d'acides aminés provenant d'un polypeptide env du VIH-I.
6. Produit d'assemblage d'ADN recombinant selon la revendication 5, dans lequel la séquence d'ADN code pour un polypeptide env complet.
- 20 7. Produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** la séquence d'ADN code pour une séquence d'acides aminés provenant d'un polypeptide gag du VIH-I.
8. Produit d'assemblage d'ADN recombinant selon la revendication 7, dans lequel la séquence d'ADN code pour un polypeptide gag complet.
- 25 9. Cellule comprenant un produit d'assemblage d'ADN recombinant selon l'une quelconque des revendications 1 à 8, la cellule exprimant la séquence antigénique d'acides aminés du VIH-I et étant exempte d'autres cellules n'exprimant pas la séquence antigénique d'acides aminés du VIH-I.
- 30 10. Cellule selon la revendication 9, le produit d'assemblage d'ADN recombinant comprenant un système de réplication reconnu par la cellule.
11. Cellule selon la revendication 10, la cellule étant un eucaryote.
- 35 12. Cellule selon l'une quelconque des revendications 9 à 11, qui est une levure.
13. Procédé pour la production d'un polypeptide recombinant comprenant une séquence antigénique d'acides aminés du VIH-I, dans lequel on cultive une population de cellules selon la revendication 9, dans des conditions dans lesquelles le polypeptide recombinant est exprimé.
- 40 14. Procédé selon la revendication 13, dans lequel les cellules sont des eucaryotes.
15. Procédé selon la revendication 13, dans lequel les cellules sont des bactéries ou des levures.
- 45 16. Analyse immunologique pour la détection d'anticorps dirigés contre le VIH-I dans un échantillon présumé contenir les anticorps, **caractérisée en ce qu'**au moins un polypeptide recombinant est utilisé pour fixer les anticorps et le polypeptide recombinant comprend une séquence antigénique d'acides aminés env ou gag du VIH-I contenue dans la séquence représentée à la figure 2, ce polypeptide ne présentant immunologiquement pas de réaction croisée avec le HTLV-I ni le HTLV-II.
- 50 17. Analyse immunologique selon la revendication 16, dans laquelle au moins une séquence d'acides aminés env et une séquence d'acides aminés gag sont utilisées pour fixer les anticorps.
- 55 18. Réactif de diagnostic ou immunogène capable de fixer un anticorps anti-VIH-I dans du sérum humain, **caractérisé en ce que** ledit réactif ou ledit immunogène consiste en un antigène comprenant un fragment immunogène d'au moins sept acides aminés d'un polypeptide env ou gag du VIH-I, ce fragment ne présentant immunologiquement pas de réaction croisée avec le HTLV-I ni le HTLV-II et ayant une séquence contenue dans la séquence représentée à la figure 2.

19. Polypeptide recombinant, **caractérisé en ce qu'il** est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 5.
20. Polypeptide recombinant, **caractérisé en ce qu'il** est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 6.
21. Polypeptide recombinant, **caractérisé en ce qu'il** est produit par une cellule transformée par un produit d'assemblage d'ADN recombinant selon la revendication 7.
22. Polypeptide recombinant selon la revendication 21, dans lequel la séquence d'acides aminés gag comprend gag-p16.
23. Polypeptide recombinant selon la revendication 21, dans lequel la séquence d'acides aminés gag comprend gag-p25.
24. Polypeptide recombinant selon la revendication 21, dans lequel la séquence d'acides aminés gag comprend une protéine de fusion de séquences d'acides aminés gag-p16 et gag-p25.
25. Article de fabrication pour utilisation dans une analyse immunologique pour des anticorps dirigés contre le VIH-I, **caractérisé en ce qu'il** comprend un support solide sur lequel est fixé un polypeptide recombinant selon la revendication 19.
26. Article de fabrication pour utilisation dans une analyse immuriologique pour des anticorps dirigés contre le VIH-I, **caractérisé en ce qu'il** comprend un support solide sur lequel est fixé un polypeptide recombinant selon la revendication 21.
27. Séquence d'ADN codant pour un polypeptide de VIH-I dérivé d'un phage choisi parmi ARV-2(7D) (ATCC n°40143) et ARV-2(8A) (ATCC n°40144).
28. Produit d'assemblage d'ADN recombinant capable d'exprimer un polypeptide antigénique recombinant du VIH-I dérivé de l'organisme ATCC n°53246.
29. Polynucléotide isolé comprenant un fragment d'au moins 21 pb de la région gag ou env de la séquence ARV-2 de la figure 2, ledit polynucléotide n'ayant pas plus de 180 pb.

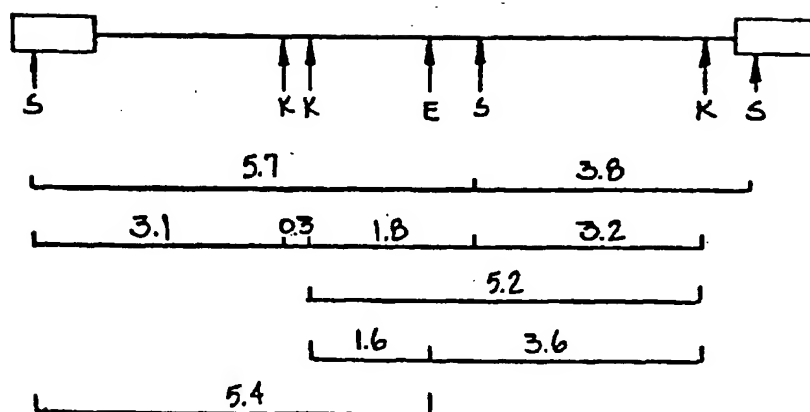


FIG. 1

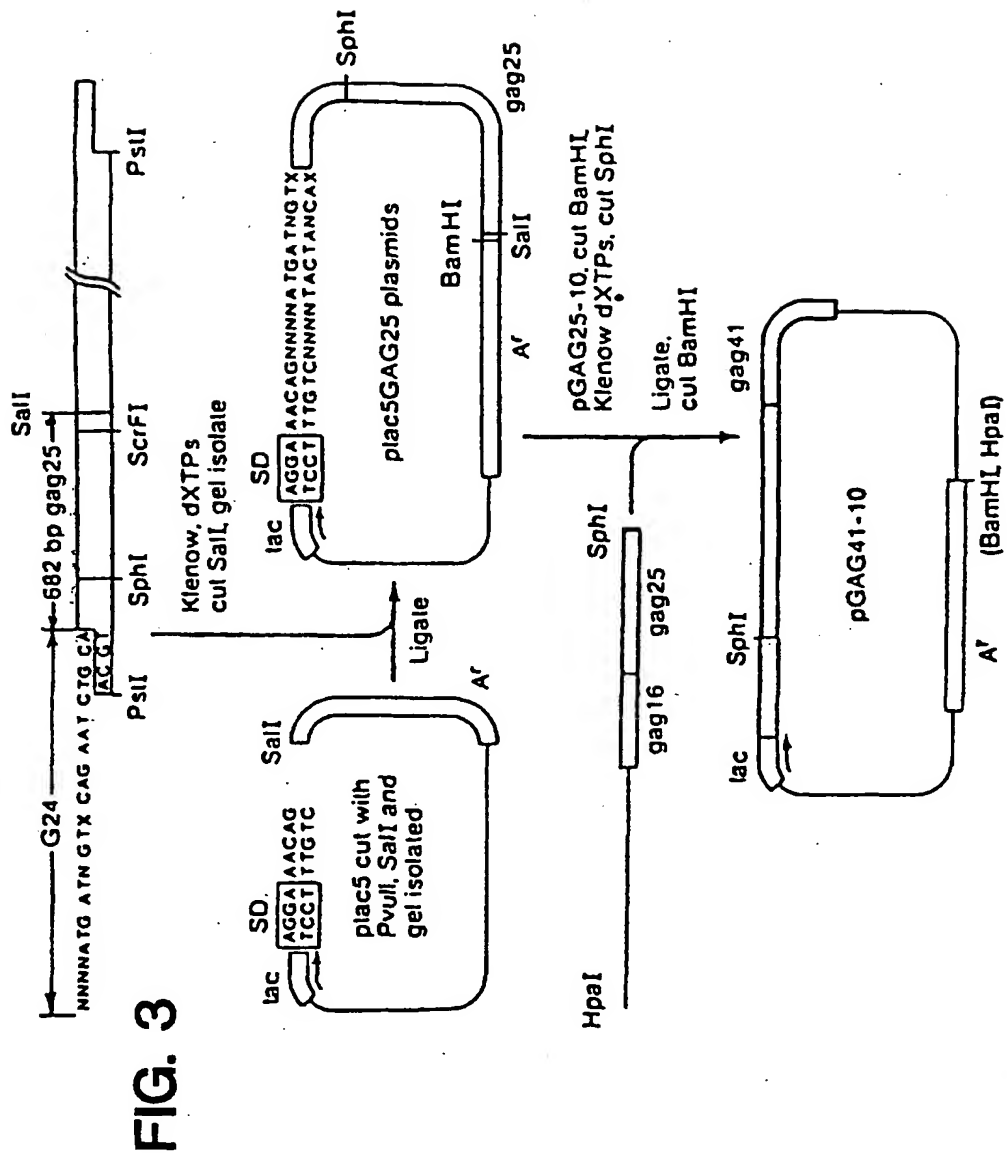
**G  
A  
G**

P  
O  
L

22

**L  
T  
R**

23





**FIG. 4**

[illegible]

FIG. 5

FIG. 5

ntac 5 Promoter

Position	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
Sequence	CGAGAG																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

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FIG. 6

5' MetGlnAArgGlyAsnPhcAArg<sup>3'</sup>AsnGlnAArgLysThrValLysCysPheAsnCyasGlyLys  
 TATTATGCAAGAGGTAACCTTCAGGGAATCAAGAGAAAGACCGTTAAGTGTTCACACTGTGGTAAG  
 ATAAATACGTTTCTCCATTGAAGTCT<sup>5'</sup>AGTTCCTTCGGCAATTCACAAAGTTGACACCATTC  
 3' 10 mnl1, 23 hinf1,  
 63 GluGlyHisIleAlaLysAsnCyasAArgAlaProAArgLysLysAlaCystrPArgCyasGly  
 GAAGGTCACATCGCTAAGAACTGTAGAGCTCCAAAGAAAGAGGCTTGTGGAGATGTGGT  
 CTTCCAGTGTAGCGATTCTTGACATCTCGAGGTTCTTCTTCCTCCGAAACAACCTCTACACCA  
 76 dde1, 88 ban2 hglA hglJ11 sao1 sdu1, 89 alu1,  
 123 ArgGluGlyHisGlnMetLysAspCystrGluAArgGlnAlaAsnPhcLeuGlyLysIle  
 AGAGAAGGTCACCAAAATGAAGGACTGTACCGAAAGACAAAGCTAATCTTCTGGGTAAAGATC  
 TCTCTTCCAGTGGTGTACTTCTCTGAATGGCTTCTGTTCGATTGAAGAACCCATCTCTAG  
 129 bstE2, 131 hph, 148 rsa1, 161 alu1, 178 bgl11 xho2, 179  
 sau3a,  
 183 TcPProSerTylLysGlyAArgProGlyAsnPhcLeuGlnSerAArgProGluProThrAla  
 TGGCCATCTTACAGGGTGAAGCCAGGTAACTTCTTGCAATCCAGACCAGAACCAACCGCT  
 AACCAGTAGAATGTTCCCTCTCTGTCCTGATGAAGAACGTTAGGTCGTGCTTGGTTGGCGA  
 183 ball oir1 hae1, 184 hae111, 199 acc1, 204 apy1 ecor11 so  
 rfi,  
 243 ProProGluGluSerPheAArgPhcGlyGluGluLysThrThrProSerGlnLysGlnGlu  
 CCACCTGAAGAAAGTTTCAGGTTTCGGGTGAAGAAATAGACCCCAATCICAAAAGCAAGAA  
 GGTGGACTTCTTTCAAAGTCCAAAGCCACTTCTTCTCGGTGGGTAGAGTTTTCGTTCCT  
 249 mbo11, 267 hph, 270 mbo11,  
 303 ProIleAspLysGluLeuTyrProLeuThrSerLeuAArgSerLeuPhcGlyAsnAspPro  
 CCAATCGACAAAGGAATGTACCCATTCACCTCTTGTGAGATCCTTGTGGTAACGATCCC  
 GGTTAGCTGTTCCTTAACTAAGTGGGTAACTGGAGAAACCTAGGAACAAGCCATTGCTAGGG  
 307 taq1, 320 rsa1, 331 mnl1, 339 xho2, 340 sau3a, 357 sau3a  
 , 361 mnl1, 362 avai xho1,  
 363 SerSerGlnOP AM  
 TCGAGCCCAATGATAG  
 AGCTCGGTACTATCAGCT  
 363 taq1, 377 acc1 hind11 sal1

**FIG. 7**